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YOUR BODY IN FLIGHT

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JULY 20, 1943

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YOUR BODY IN FLIGHT

An Illustrated

"Book of Knowledge"

for the Flyer

Prepared by the

AERO MEDICAL LABORATORY

Engineering Division, Materiel Command

Wright Field, Dayton, Ohio

Published by the

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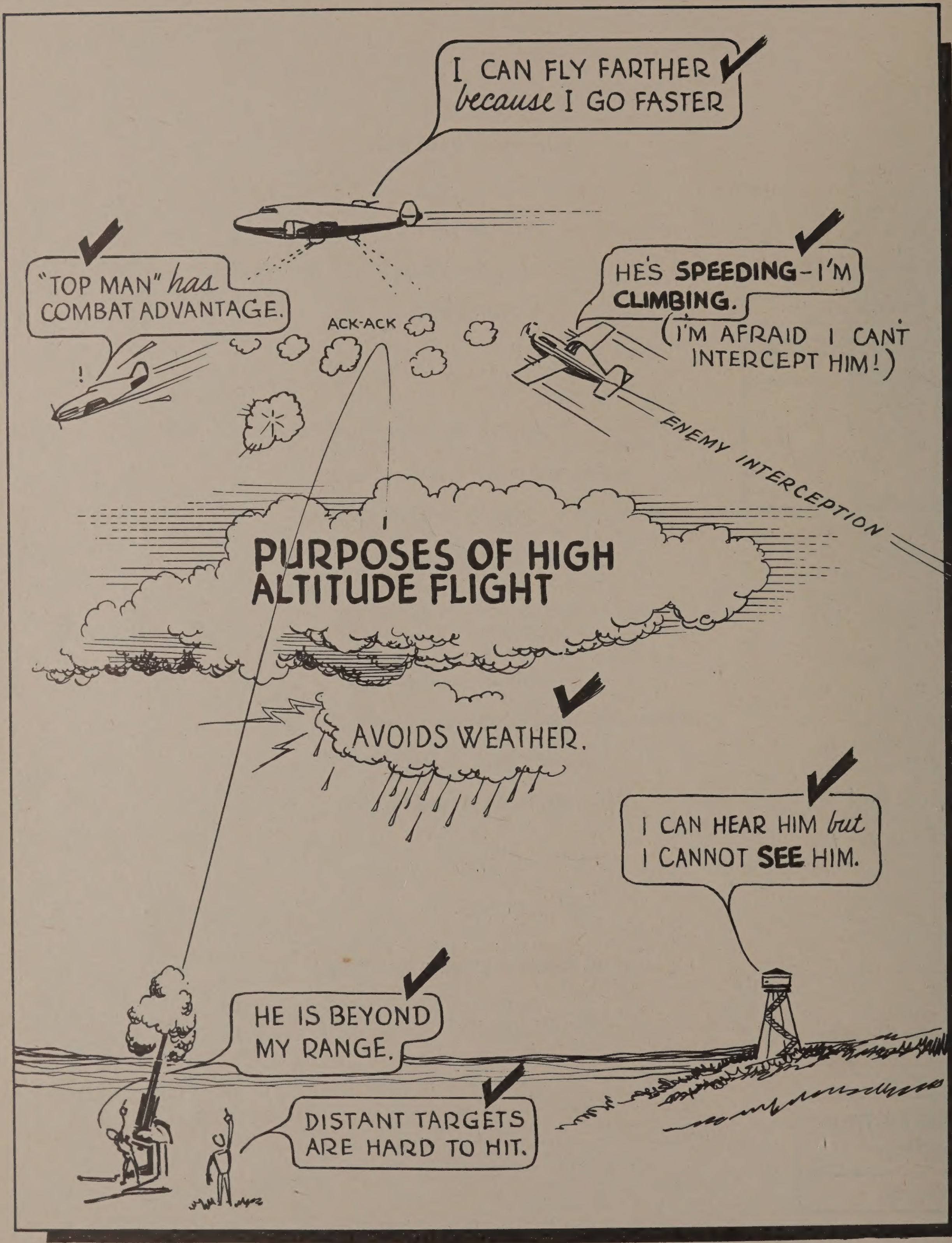
AIR SERVICE COMMAND

Patterson Field, Fairfield, Ohio

UNITED STATES ARMY AIR FORCES


I CAN FLY FARTHER because I GO FASTER
"TOP MAN" has COMBAT ADVANTAGE.
HE'S SPEEDING-I'M CLIMBING.
(I'M AFRAID I CAN'T INTERCEPT HIM!)
ACK-ACK
ENEMY INTERCEPTION
PURPOSES OF HIGH ALTITUDE FLIGHT
AVOIDS WEATHER.
I CAN HEAR HIM but I CANNOT SEE HIM.
HE IS BEYOND MY RANGE.
DISTANT TARGETS ARE HARD TO HIT.

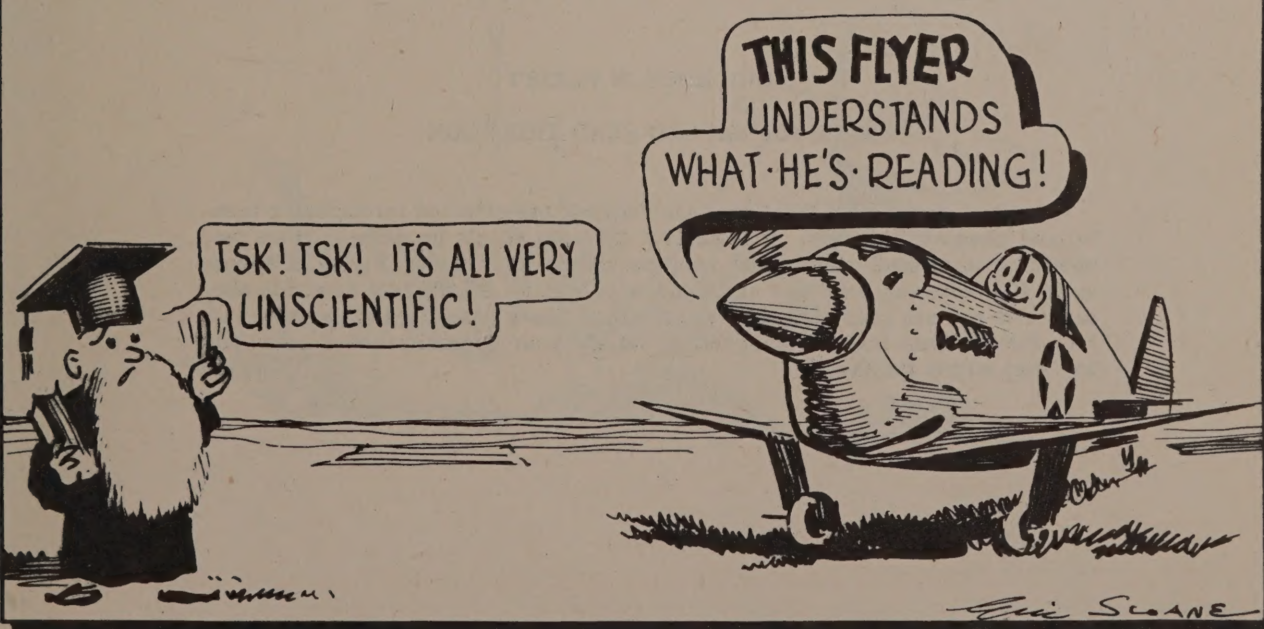
Note

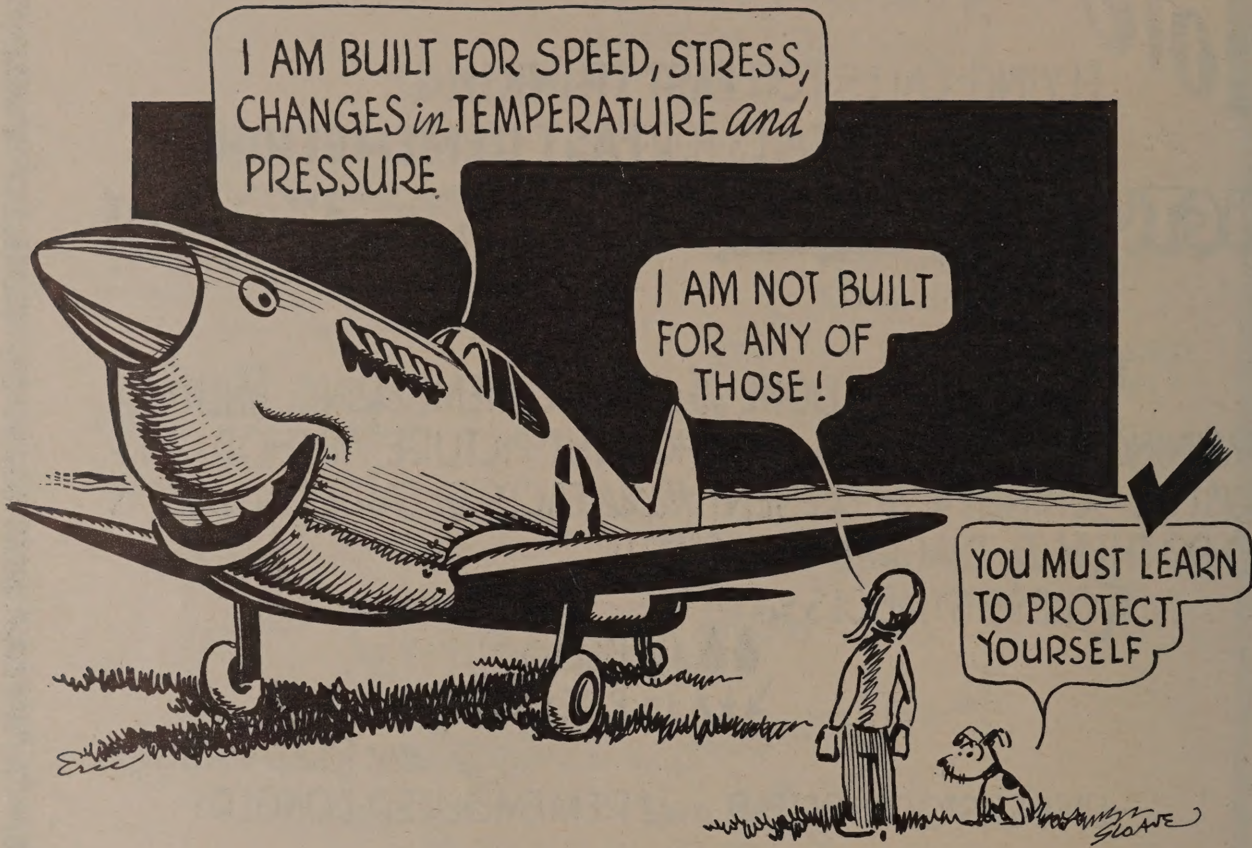
FLYING·CALLS·FOR·**FAST THINKING!**
FAST·THINKING·CALLS·FOR·**FAST·REMEMBERING!**

PICTURES *are* **EASIER** *to remember than* **WORDS!**

THIS·BOOK *is* DONE *for* FAST·REMEMBERING. MILITARY TRAINING *has* ACCEPTED *the* "THOUGHT-PICTURE" METHOD: IT·IS JUST *as* SCIENTIFIC *to* PRESENT *these* FACTS *in* CARTOON *as* IT·IS TO·DO·THEM *by* DIAGRAM *and* CHART.

THESE·SYMBOLS ↘
(= BLOOD)
(= PRESSURE)
are READ·FASTER, UNDERSTOOD·BETTER *and* REMEMBERED·LONGER!





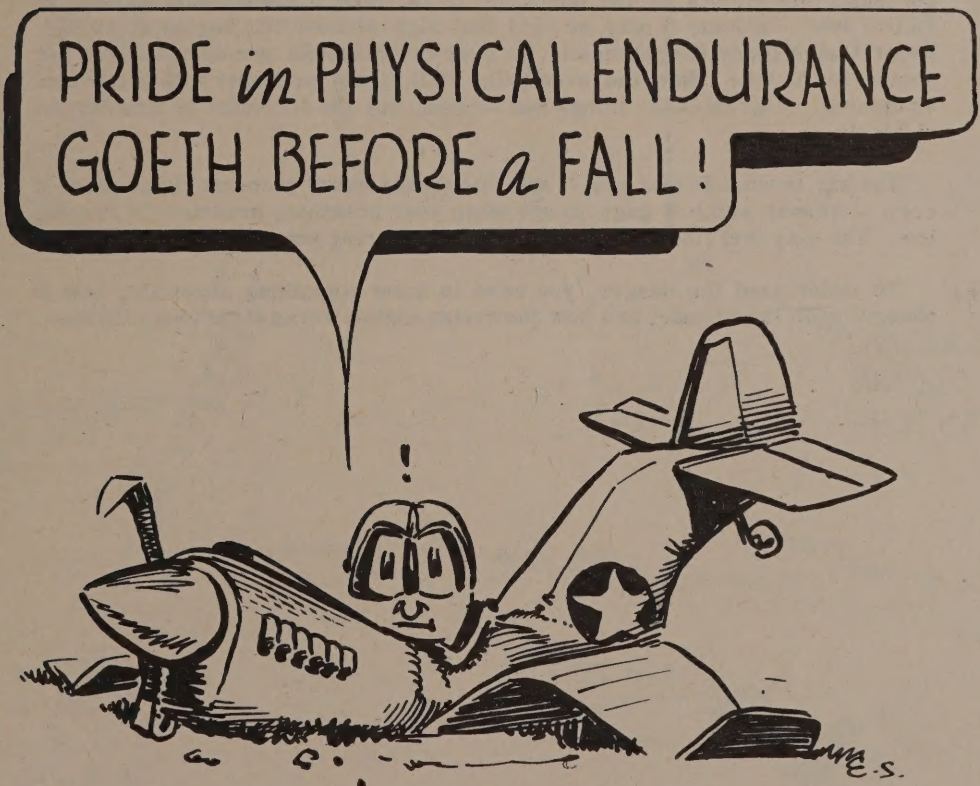
YOUR BODY IN FLIGHT

WHY YOU SHOULD READ THIS BOOK

You, as a member of the Army Air Forces, are selected for superior mental and physical abilities. It is natural that you should be more curious than nonflying personnel about what happens inside your body. Flying at speeds up to 400 miles an hour and at altitudes as high as 40,000 feet demands obedience to certain laws of nature which exact heavy penalities of any who violate them. This book is designed to satisfy your curiosity and tell you how to "stay within the law."

It is not easy. On the ground, man's body - with the aid of proper food, clothing, shelter, and in some cases, a little padding - is ordinarily well adjusted to such natural forces as temperature, gravity, pressure, and inertia. As a ground animal, he can "take it." But when he rises to 10,000 feet and more, these same forces may run to extremes far beyond the body's "breaking load." Planes can be built to take such stresses and strains, but flyers, physiologically speaking, are born and not made. The alternative to building a flying animal is to find how to protect the human body from its own limitations when in flight.

The Army Air Forces is devoting vast quantities of time and effort in the laboratory, in the examining rooms, and in the air to equip earth-bound man for safe and efficient flight. Yet difficult as some of the research problems are, the toughest job is to get the flyer to make use of what has been learned. The scientific men are doing their job, but putting their knowledge to use is <u>your</u> job. It is your job because application of this knowledge will help you get more planes over the target, bring more planes back, and increase your own chances of survival. The following pictures and paragraphs tell, as simply and as painlessly as possible, how to do it.



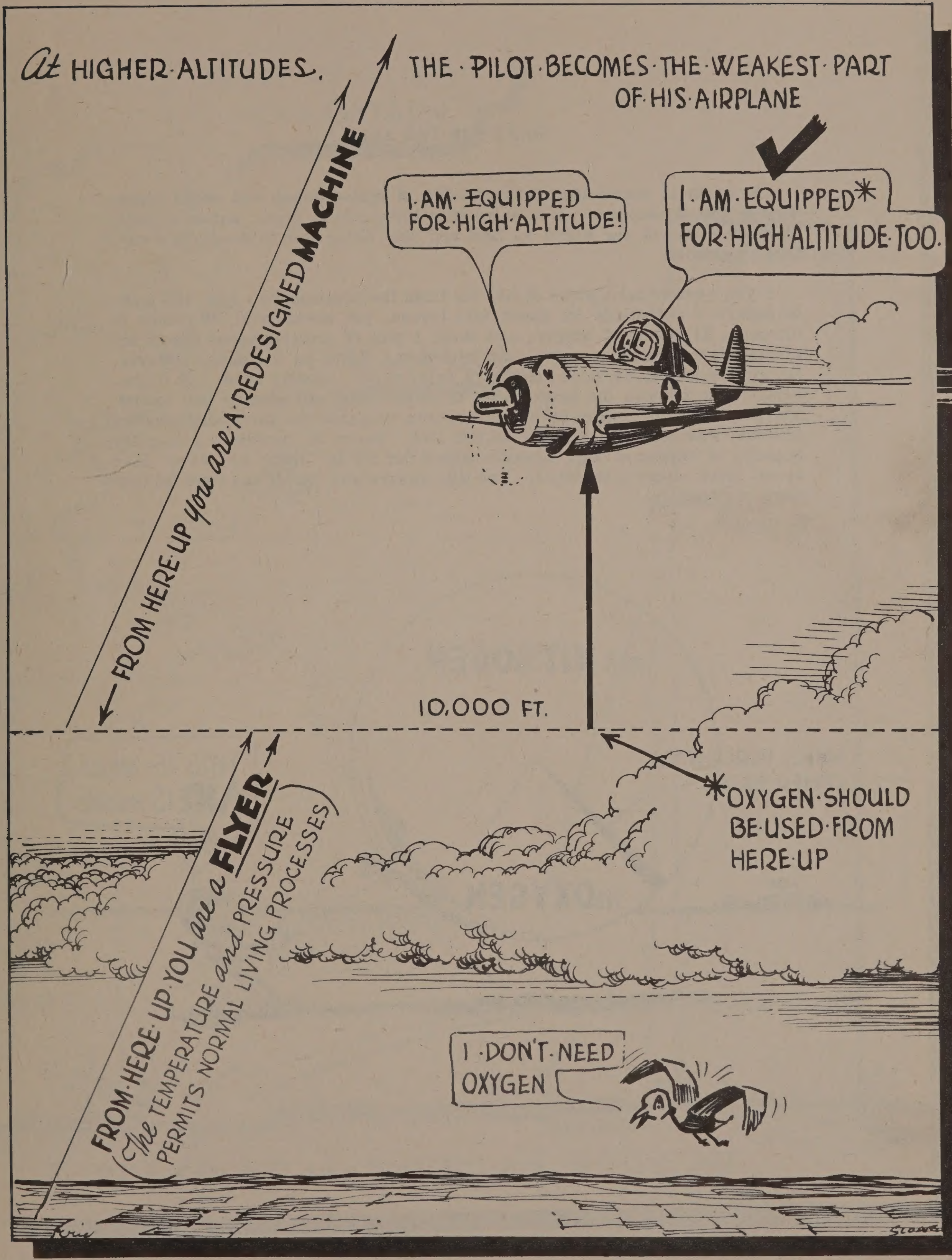
WHERE THE TROUBLE BEGINS

Aviation was born and reared scarcely a hop, skip, and a jump from the ground compared to the altitudes reached by modern planes. Flyers encountered no great difficulties in adjusting themselves to conditions ordinarily encountered at low altitudes, and went on "upstairs" with their hand on the control wheel and their eyes on the manifold and fuel pressure gages. They scarcely thought of how their own human engines were turning over.

These engines sometimes lagged and once in a while "conked out." Changes in the characteristics of the atmosphere, or air, in the higher altitudes were to blame. The changes - and this has been proved beyond doubt - begin having important effects on the operation of the body's combustion system at 10,000 feet. In fact, it may be said that high-altitude life begins at 10,000. Below that altitude the physically fit body can make its own adjustments, but above that it will labor and eventually stall if not provided with protective equipment. A great many things can happen, but the foremost is running out of breath.

The big trouble is that you - and this means every member of the plane's crew - cannot watch a gage to see when your breathing pressure is running low. You may feel fine when the needle is fluttering near zero.

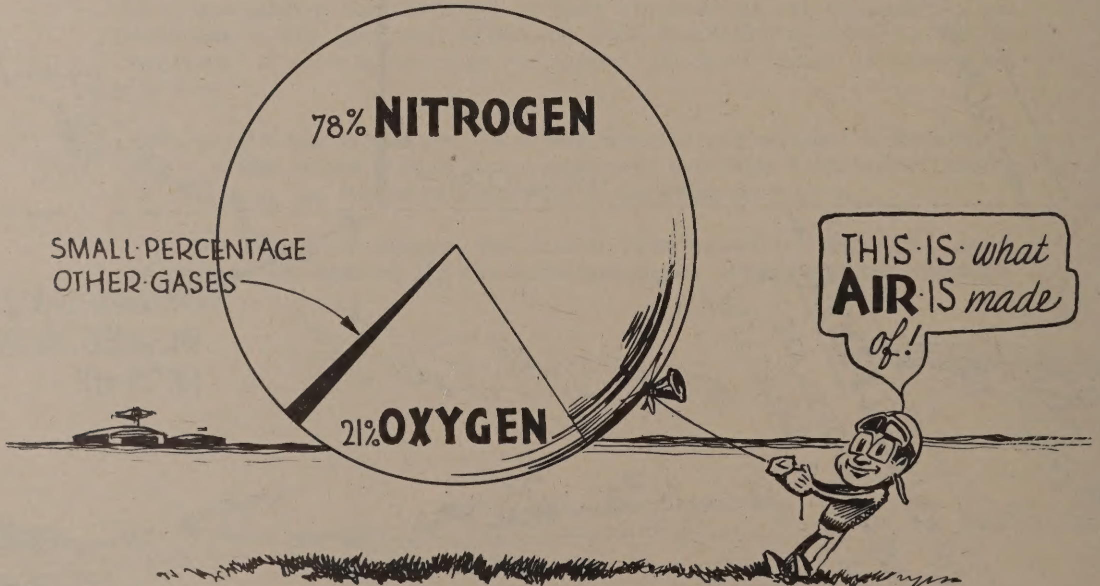
To understand the danger, you need to know something about air, how it changes with the altitude, and how the human engine works at various altitudes.

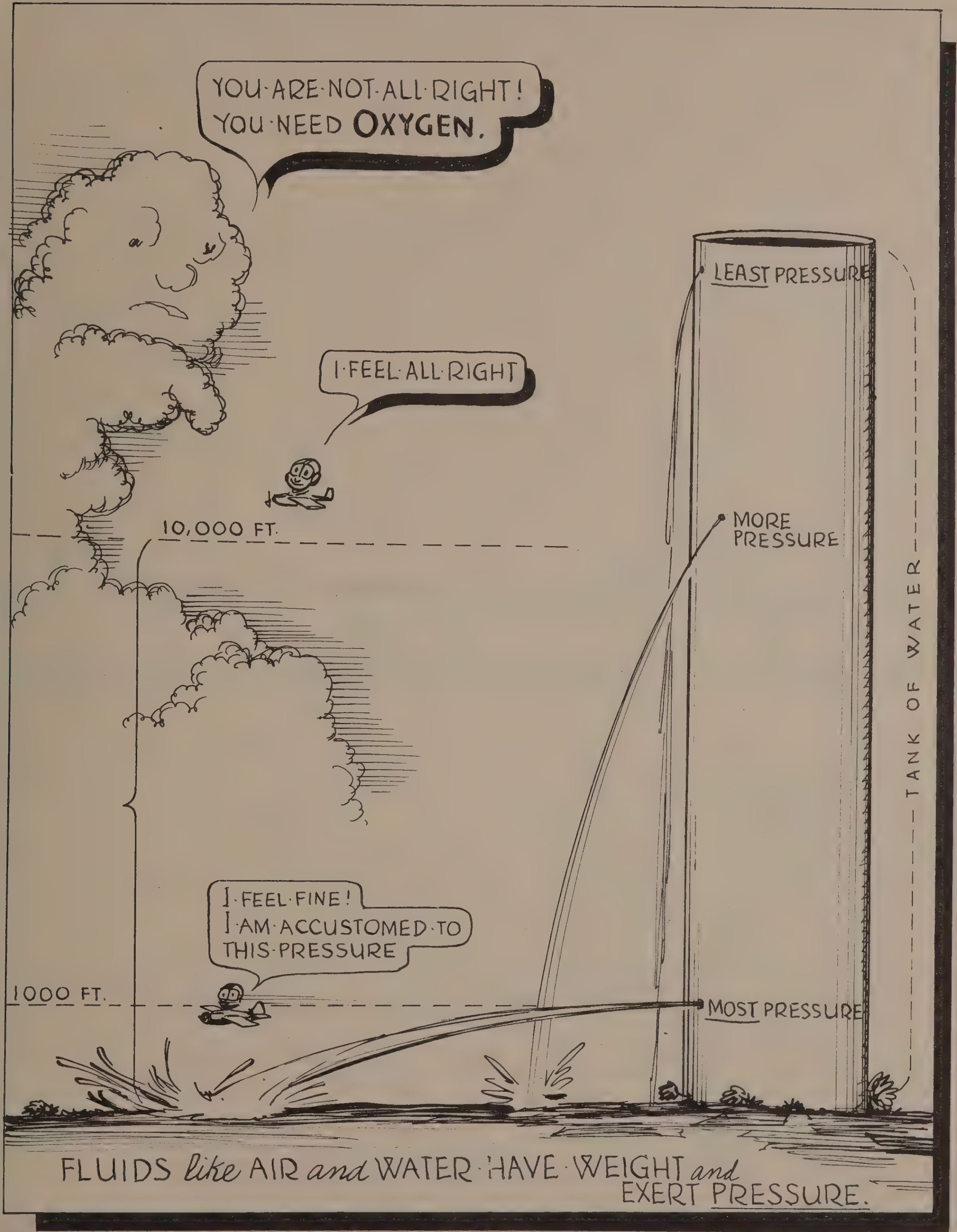

At HIGHER ALTITUDES, THE PILOT BECOMES THE WEAKEST PART OF HIS AIRPLANE
FROM HERE UP you are A REDESIGNED MACHINE
I AM EQUIPPED FOR HIGH ALTITUDE!
I AM EQUIPPED* FOR HIGH ALTITUDE TOO.
10,000 FT.
*OXYGEN SHOULD BE USED FROM HERE UP
FROM HERE UP YOU are a FLYER
(The TEMPERATURE and PRESSURE PERMITS NORMAL LIVING PROCESSES)
I DON'T NEED OXYGEN

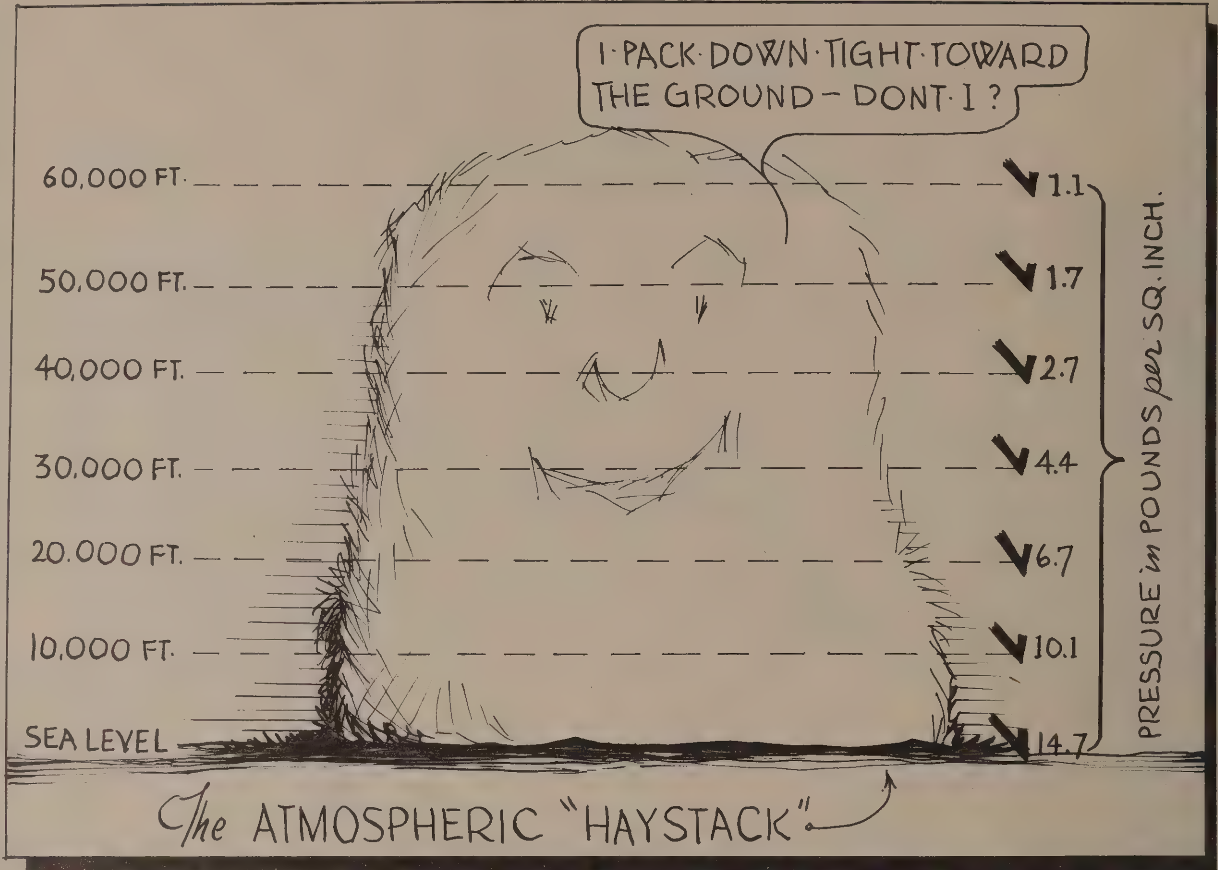
WHAT'S IN THE AIR

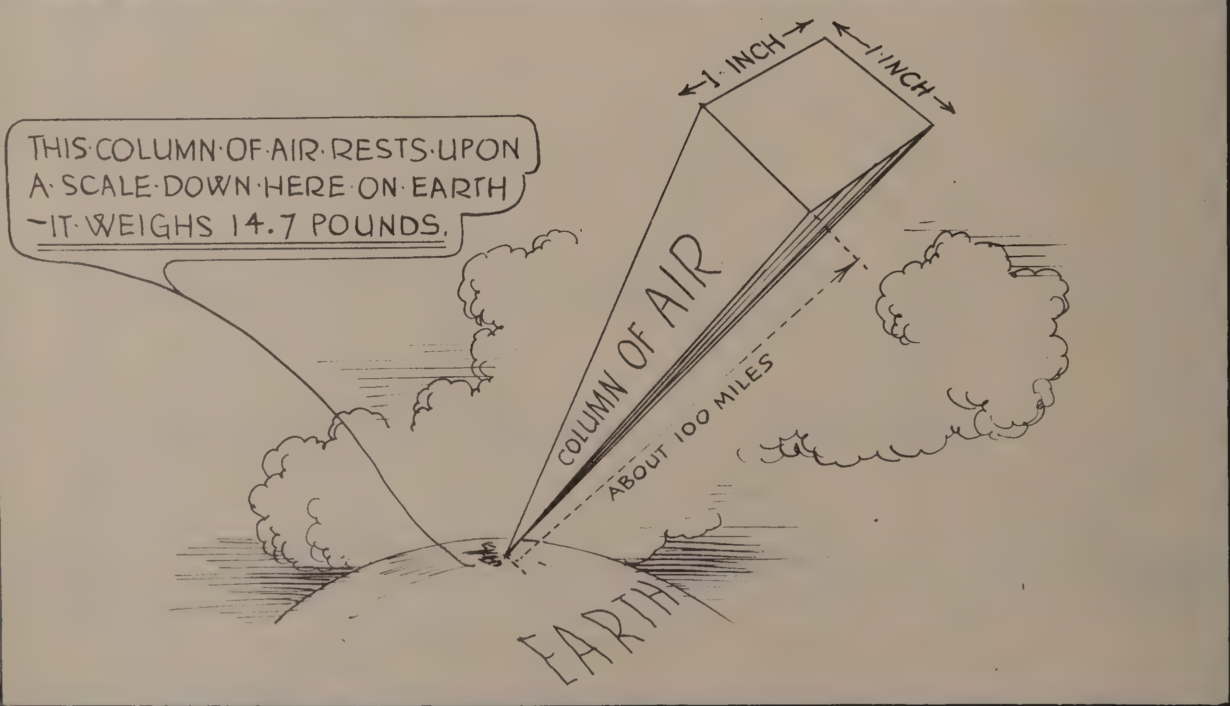
The earth is surrounded by a covering of mixed gases and water vapor. This is the atmosphere. It is more than 100 miles in depth, and is actually as much a part of our world as land and sea, being held to the earth's surface by gravity.

If you were to cut a piece of dry air from the atmosphere - say, 100 inches square - and divide its gases into layers, you would have: 78 inches of nitrogen, 21 inches of oxygen, and about 1 inch of miscellaneous gases, including carbon dioxide, argon, and hydrogen. Taken as it comes, however, the air contains a variable amount of water vapor, usually from 1 to 5 percent. This reduces the proportions of oxygen and nitrogen to that extent. The percentage of oxygen in the atmosphere remains the same whatever the altitude, whether sea level or 50,000 feet. There is, however, a smaller quantity of oxygen at high altitudes where the air is "thin" or "rare" than at sea level where it is dense. You will understand this if you read the next page on pressure.




YOU·ARE·NOT·ALL·RIGHT!
YOU·NEED OXYGEN.
I·FEEL·ALL·RIGHT
10,000 FT.
LEAST PRESSURE
MORE PRESSURE
TANK OF WATER
I·FEEL·FINE!
I·AM·ACCUSTOMED·TO
THIS·PRESSURE
1000 FT.
MOST PRESSURE
FLUIDS like AIR and WATER·HAVE·WEIGHT and
EXERT PRESSURE.

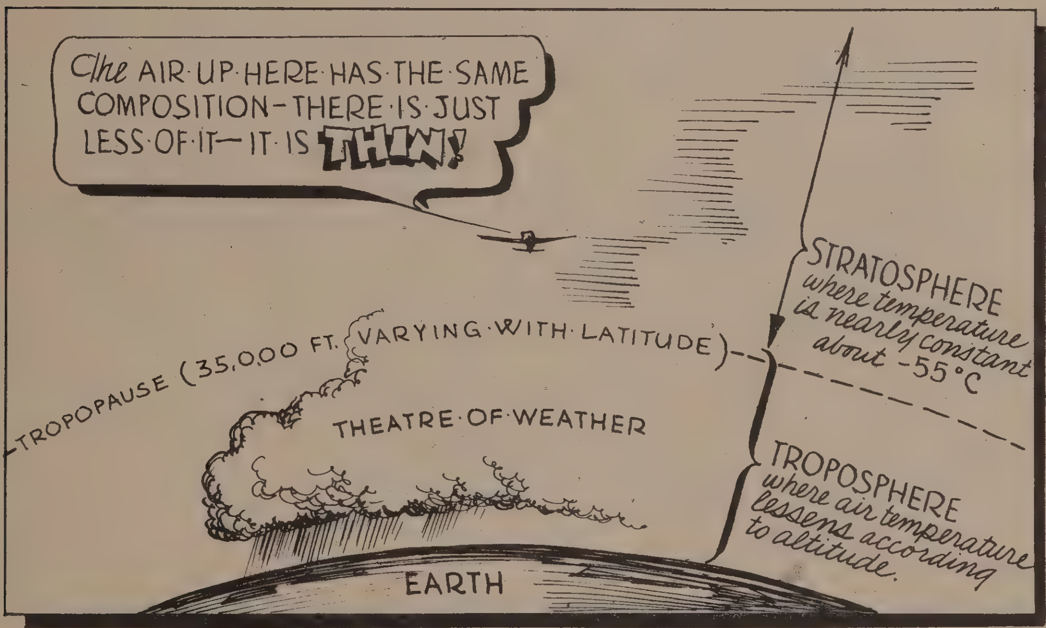

I·PACK·DOWN·TIGHT·TOWARD THE GROUND – DONT·I ?
60,000 FT.
50,000 FT.
40,000 FT.
30,000 FT.
20,000 FT.
10,000 FT.
SEA LEVEL
1.1
1.7
2.7
4.4
6.7
10.1
14.7
PRESSURE in POUNDS per SQ. INCH.
The ATMOSPHERIC "HAYSTACK"


THIS·COLUMN·OF·AIR·RESTS·UPON A·SCALE·DOWN·HERE·ON·EARTH –IT·WEIGHS 14.7 POUNDS.
1·INCH
1·INCH
COLUMN OF AIR
ABOUT 100 MILES
EARTH

WHAT CAUSES ATMOSPHERIC PRESSURE

The atmosphere is "piled" on the earth's surface like a haystack. The bottom layers are packed down and therefore are heavier than the layers near the top where the hay is loose.

If you could box in a vertical column of air 1-inch square from sea level to the upper limit of the atmosphere and set it on a scale, you would find it weighs 14.7 pounds. But because the gases in the air "pack down," the weight of the column would be greater at the bottom than at the top. Whereas the pressure per square inch would be 14.7 pounds at zero altitude, it would be only 6.7 at 20,000 feet and 2.7 at 40,000 feet.

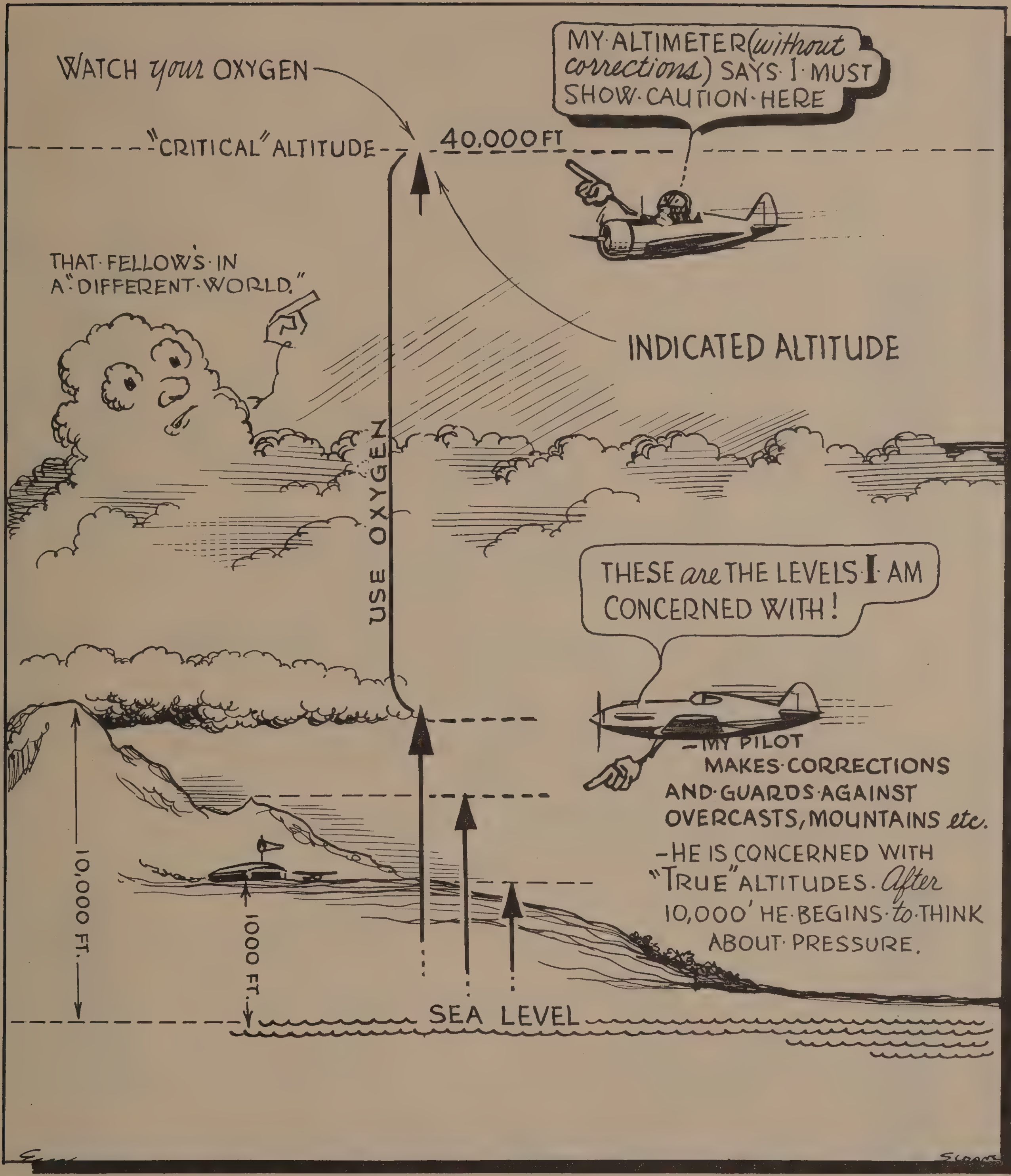


HOW YOU MEASURE PRESSURE

You can measure the pressure of atmosphere with a tube of mercury sealed at the top and set vertically in a cup. A barometer works on the same principle. At sea level, under normal conditions, the weight of the atmosphere pushes the column of mercury to a height of 760 millimeters, or nearly 30 inches. At an altitude of 18,000 feet, the mercury rises only to about 380 millimeters, or half as far. At 33,500 feet, the pressure is 190 millimeters, or one-fourth as much as at sea level.

The barometer in an airplane is the altimeter. It is an instrument which records the pressure of the atmosphere in terms of feet above sea level. This is done for convenience, because the actual number of feet you are above sea level may vary from the altimeter reading. The reason for this is that the altimeter is scaled to a standard pattern of temperatures normally found at given altitudes. For the reason that gases expand when heated and contract when cooled, the actual temperature at any altitude may shift from the normal with the weather or the season.

The altimeter reading gives you the indicated altitude. It is this reading that governs our oxygen needs. True altitude, important in navigating your airplane over mountains and in making instrument landings, is obtained from the indicated altitude by mathematical correction for outside temperature and instruments errors. The pilot is used to thinking in terms of true altitude, but this reading can get him into trouble when it is a question of how much altitude his body can stand - with or without an oxygen mask. Remember that in this book we are dealing with the indicated altitude.


MY ALTIMETER (without corrections) SAYS I MUST SHOW CAUTION HERE
WATCH your OXYGEN
"CRITICAL" ALTITUDE
40,000 FT
THAT FELLOW'S IN A "DIFFERENT WORLD."
INDICATED ALTITUDE
USE OXYGEN
THESE are THE LEVELS I AM CONCERNED WITH!
—MY PILOT MAKES CORRECTIONS AND GUARDS AGAINST OVERCASTS, MOUNTAINS etc.
—HE IS CONCERNED WITH "TRUE" ALTITUDES. After 10,000' HE BEGINS to THINK ABOUT PRESSURE.
10,000 FT.
1000 FT.
SEA LEVEL

HOW YOU BREATHE

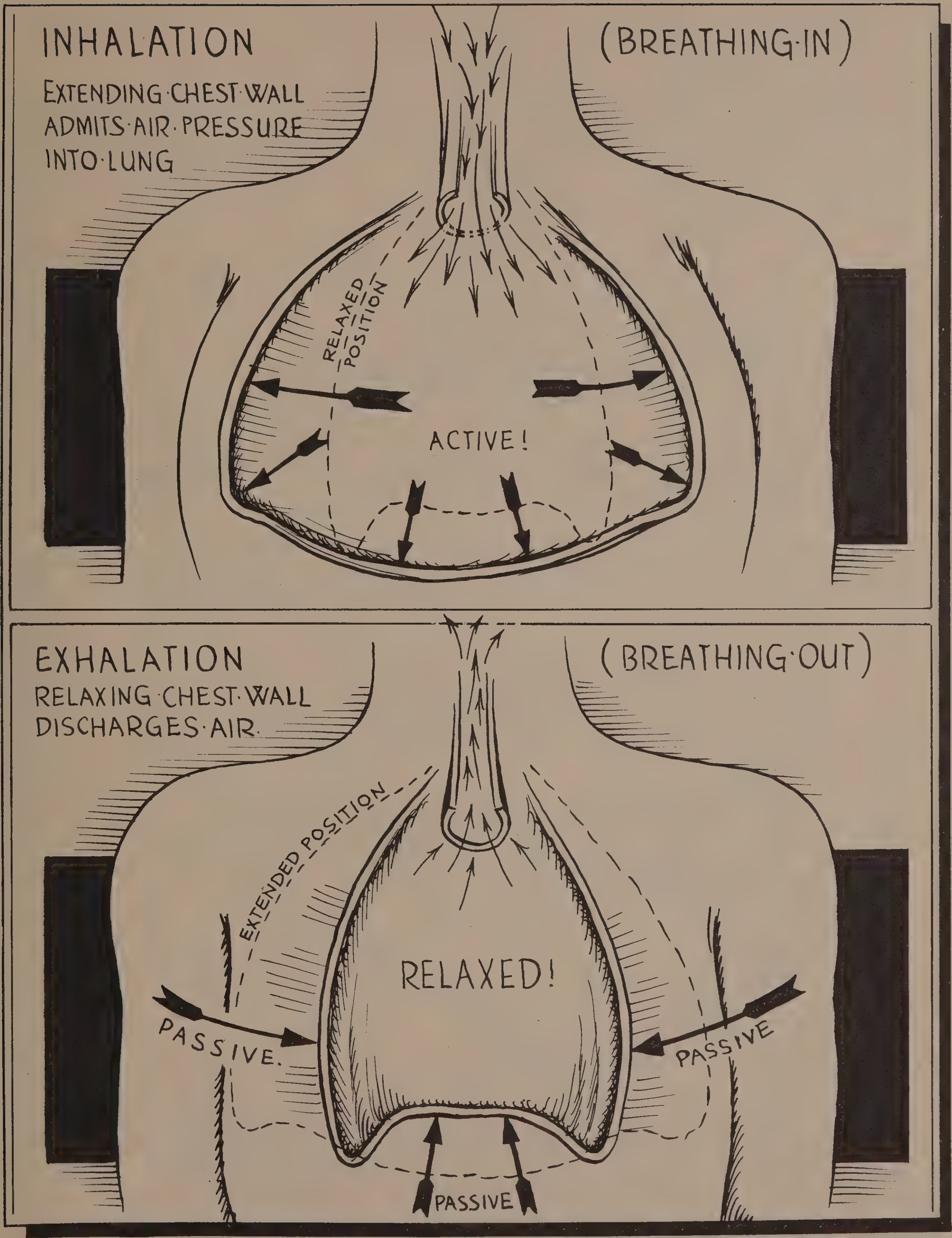
Oxygen is literally the "breath of life." It is necessary in the combustion of all fuels - including gasoline and food. In fact, the body uses oxygen in much the same fashion as an internal combustion engine. It combines with a carbon compound to produce driving energy. Carbon dioxide is given off as a waste gas.

The body obtains its oxygen by breathing air through the lungs. The lungs operate like a cylinder pump, the piston action coming from chest muscles which raise the ribs and from contraction of the diaphragm below the lungs.

Inspiration, or breathing in, pulls the chest wall and diaphragm away from the lungs and creates a negative pressure, or suction. The pressure of the atmosphere forces the air to rush in through the windpipe and inflate the lungs. This is the active phase of respiration and requires muscular effort.

Expiration, or breathing out, takes place when the chest muscles and diaphragm are relaxed. In this passive phase the chest cavity becomes smaller and pushes the air out of the lungs.

The average man at rest takes in at each breath enough air to fill a box a trifle over 3 inches square, or 30 cubic inches. He does this from 12 to 16 times a minute.


INHALATION
(BREATHING·IN)
EXTENDING·CHEST·WALL
ADMITS·AIR·PRESSURE
INTO·LUNG
RELAXED POSITION
ACTIVE!
EXHALATION
(BREATHING·OUT)
RELAXING·CHEST·WALL
DISCHARGES·AIR
EXTENDED POSITION
RELAXED!
PASSIVE.
PASSIVE
PASSIVE

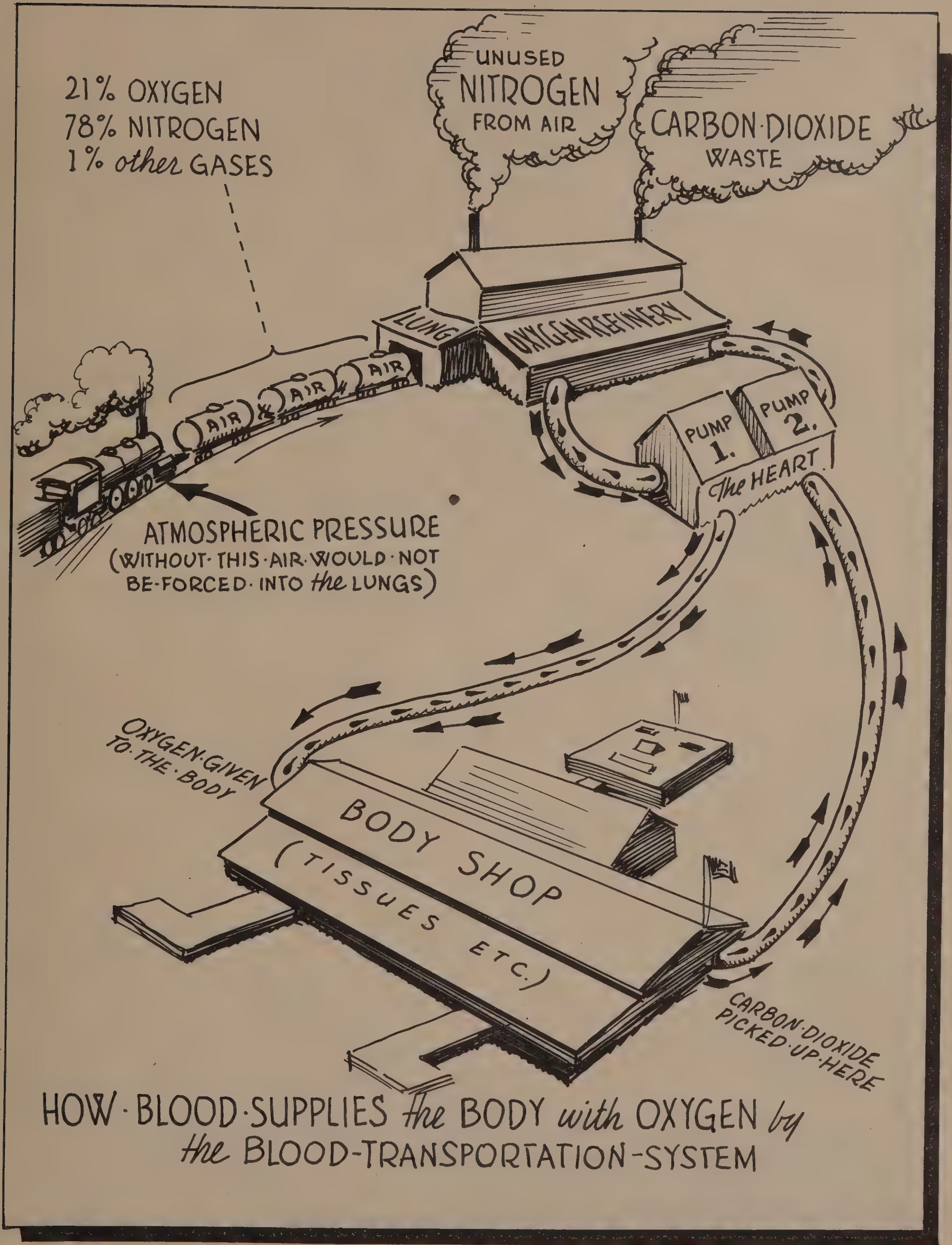
HOW THE BLOOD TRANSPORTS OXYGEN

Oxygen is extracted from the air passing in and out of the lungs by millions of remarkable little sacs called the alveoli (pronounced al-VEE-o-lie). These tiny pockets of delicate membrane are interlaced with a network of fine blood vessels. Their total surface area is between 700 and 800 square feet.

These air sacs are the point where the oxygen enters the blood stream, and where carbon dioxide leaves it. Their walls and the walls of the adjacent blood vessels are so thin that any difference in pressure on either side will cause gas to pass through. The blood is continually moving through the lungs, and the exchange of oxygen and carbon dioxide takes only a second or two.

The lung's blood vessels are part of the circulatory system, which consists of (1) arteries connecting with the network of blood vessels in the body and of (2) veins completing the circuit back to the lungs. The oxygen entering the blood is loaded on a continuous fleet of efficient carriers, the red blood cells. The cells enable the blood to carry 100 times as much oxygen as can be dissolved in water.

Thus, we see that the lungs serve as a supply depot and refinery for oxygen and a dump for carbon dioxide. The blood, acting as a hydraulic conveyor system, is pumped, as everyone knows, by the heart. The oxygen is carried into the body's tissues, where it goes to work in a chemical laboratory burning food to produce energy so the body can work.

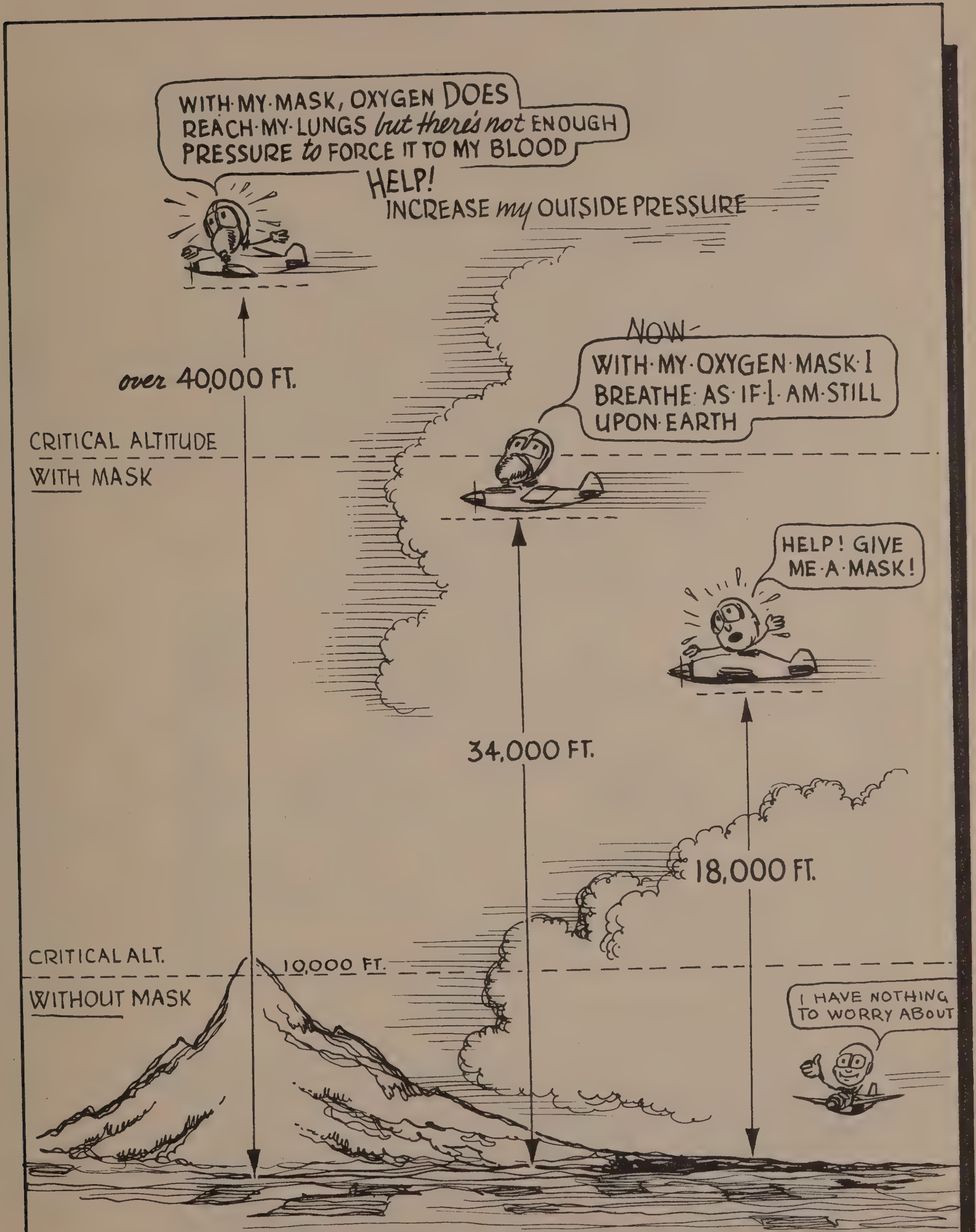

UNUSED
NITROGEN
FROM AIR
CARBON·DIOXIDE
WASTE
21% OXYGEN
78% NITROGEN
1% other GASES
LUNG
OXYGEN REFINERY
AIR
AIR
AIR
AIR
PUMP 1.
PUMP 2.
The HEART
ATMOSPHERIC PRESSURE
(WITHOUT·THIS·AIR·WOULD·NOT
BE·FORCED·INTO the LUNGS)
OXYGEN·GIVEN
TO·THE·BODY
BODY SHOP
(TISSUES ETC.)
CARBON·DIOXIDE
PICKED·UP·HERE
HOW·BLOOD·SUPPLIES the BODY with OXYGEN by
the BLOOD-TRANSPORTATION-SYSTEM

THE PRESSURE OF OXYGEN

Oxygen moves from the lungs into the blood stream because it is under greater pressure in the air than in the blood, and a gas always diffuses from a region of higher to one of lower pressure. The atmospheric pressure of oxygen, however, is not the same as that of air, which we saw was 760 millimeters of mercury in a barometer at sea level.

Oxygen makes up only 21 percent of the air and likewise only 21 percent or 160 millimeters of the total air pressure at sea level. This is called its partial pressure. The partial pressures of nitrogen and other inert gases in the air are unimportant inasmuch as they are exhaled in the same quantity as inhaled.

While the partial pressure of oxygen is ample to supply the body with blood at ground level, its pressure decreases the same as atmospheric pressure as you rise to high altitudes.


WITH·MY·MASK, OXYGEN DOES REACH·MY·LUNGS but there's not ENOUGH PRESSURE to FORCE IT TO MY BLOOD
HELP! INCREASE my OUTSIDE PRESSURE
over 40,000 FT.
CRITICAL ALTITUDE WITH MASK
NOW- WITH·MY·OXYGEN·MASK·I BREATHE·AS·IF·I·AM·STILL UPON·EARTH
HELP! GIVE ME·A·MASK!
34,000 FT.
18,000 FT.
CRITICAL ALT. WITHOUT MASK
10,000 FT.
I HAVE NOTHING TO WORRY ABOUT

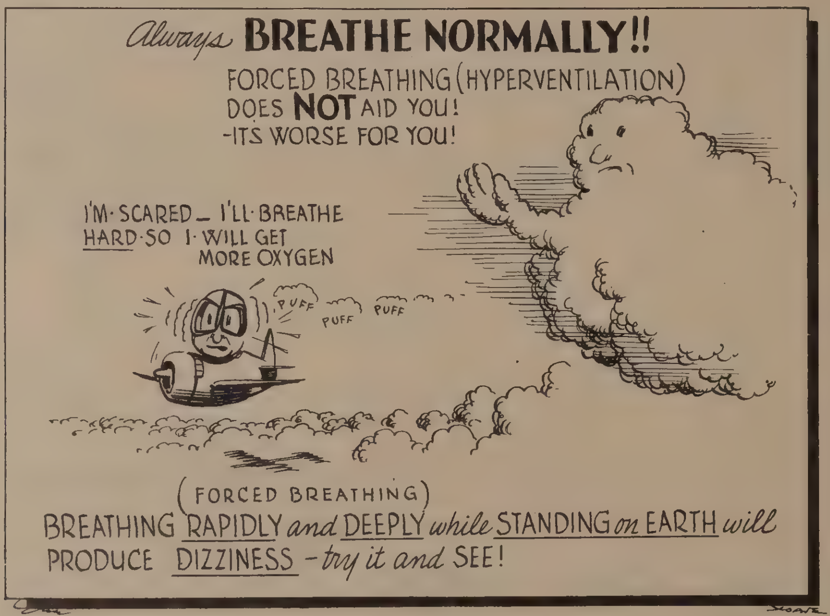
FASTER BREATHING DOESN'T HELP

You may think that a quick way of getting more oxygen at high altitudes is to breathe faster. It is true that this will get more oxygen into the blood, but it will also knock you out if you keep it up. Curiously enough, this is due to the fact that carbon dioxide is eliminated too rapidly. You would think there was no harm in eliminating this gas, since it's a waste product. There isn't, unless you do it too fast.

The trouble lies in the fact that the rate of breathing is regulated primarily by the blood's carbon dioxide content, which acts as an automatic governor. The depth and speed of breathing increases as the blood's load of carbon dioxide increases, and decreases as the load decreases.

At ground level this is as it should be. There your need for oxygen depends on how hard the muscles are working. When they are exercising greater quantities of carbon dioxide are given off, which causes you to breathe faster.

At high altitudes, the supply of oxygen becomes insufficient, but there is no increase in the amount of carbon dioxide in the blood. Thus, forced breathing, or hyperventilation, merely reduces the carbon dioxide still further. The result is a slowing down of respiration and a further reduction of the amount of oxygen reaching the blood. Numbness or paralysis of the legs and arms may follow.



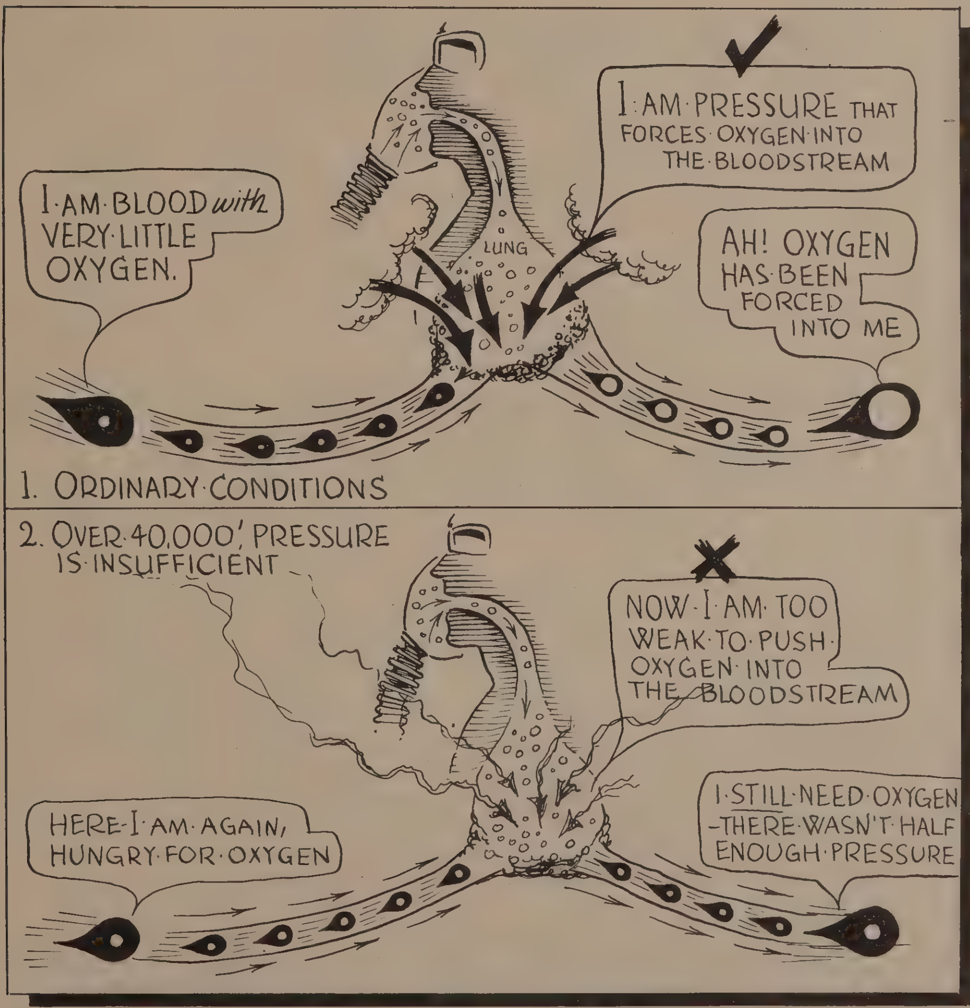
HOW YOUR OXYGEN MASK PROTECTS YOU

When the partial pressure of oxygen becomes too low to supply you with sufficient oxygen, there are two ways of meeting the situation. The most obvious is the most difficult: to increase the pressure. This is being done in high altitude flying with pressurized cabins, flying suits, and breathing apparatus, but all of these are still in the experimental stages and of no immediate concern to the man of the flying line today. The second method is to raise the proportion of oxygen in the air entering the lungs over the usual 21 percent. This is the purpose of your mask, which will raise the pressure of oxygen entering your lungs all the way to 100 percent. The mask, when used with care, will enable you to fly as high as 40,000 feet for short periods.

How an increase in the oxygen content of the air you breathe offsets reduction in partial pressure may be seen from this example: At 18,000 feet altitude, the partial pressure of oxygen is 80 millimeters, compared to 160 at sea level. If you increase the proportion of oxygen from 21 percent to 42 percent, its partial pressure is again 160 millimeters. To obtain 160 millimeters of oxygen pressure at 34,000, pure oxygen is needed. An allowance must be made for water vapor in matching breathing conditions found at ground level. Water vapor pressure in the lungs remains constant, and thus contributes an increasing percentage of the total as the air pressure is reduced.

Above 34,000 feet the oxygen in the blood decreases below normal, even with a supply of 100 percent oxygen to the lungs. The critical point is reached at 40,000 feet where 100 percent oxygen pressure is barely enough to keep the oxygen content of blood within safe limits. The period at which you will remain conscious above that altitude is a matter of minutes, despite your mask.

Without a mask, you may, if you do not exercise, keep your senses for thirty minutes at 18,000 feet; but at 25,000, consciousness will last only a few minutes; at 30,000, a minute or less; and at 35,000, thirty seconds or less. No harmful effects will result from breathing pure oxygen during air travel. It will not, as some say, make your teeth brittle or give you pneumonia.



OXYGEN WANT

When the pressure of the air is too low to force enough oxygen into his blood, the flyer suffers from anoxia (ah-NOK-see-ah), a Greek word meaning "without oxygen." The simplest words for it, however, are oxygen want. The condition can produce a multitude of ill effects, depending on the degree of want. The effects may range, in comparison, from the exhilaration of a couple of highballs to passing out from one too many.

Lack of enough oxygen in the blood is a deficiency disease which begins when the oxygen saturation of the blood in the arteries drops below 95 percent. This is the normal amount at ground level. Ninety-five percent saturation means that the blood contains from 18 to 20 percent oxygen by volume.

If you go up to 11,000 feet without an oxygen mask or to 41,000 feet with one, the blood's oxygen saturation will decrease to 85 percent. With this amount of decrease, if the ascent is fairly gradual, the flyer will probably feel fine; in fact, too good for his own welfare because he is undergoing a depletion of oxygen supply. This, if continued, will affect his brain and lead to errors of judgment. His navigation may go haywire or his aim may be off when he is most confident. The greatest danger is at night. Even a slight oxygen want, harmless in daylight, reduces one's vision. This is the first thing affected. For this reason, all flyers must use oxygen masks from the ground up on night missions.

At 13,000 feet without and 42,000 feet with a mask the oxygen saturation declines to 80 percent. Tremor of the hands and a clouding of thought and memory, as well as greater errors of judgment, are the likely penalties. At 18,000 feet without and 44,000 feet with a mask, the arterial oxygen load plummets to 70 percent; the virtual limit of human tolerance. The muscles are leaden and may hurt when worked. Fainting is frequent when fear or pain is involved. Vision, already impaired, may become double; the fingers and the face, bluish. In this way the body telegraphs the knock-out punch heading your way!

CAUSES OF OXYGEN WANT

Many factors may cause the body to starve for oxygen. Those most likely to affect the flyer fall into four classes:

1. HIGH ALTITUDE. - This is the biggest problem, as you already should suspect if you have read this book or looked at its pictures up to this point. As you go up, your oxygen supply goes down. Look at it as an air freight line, with the red blood cells as cargo planes and oxygen as the load. The full fleet is flying the route on schedule but it can't get a capacity load from the supply depot.

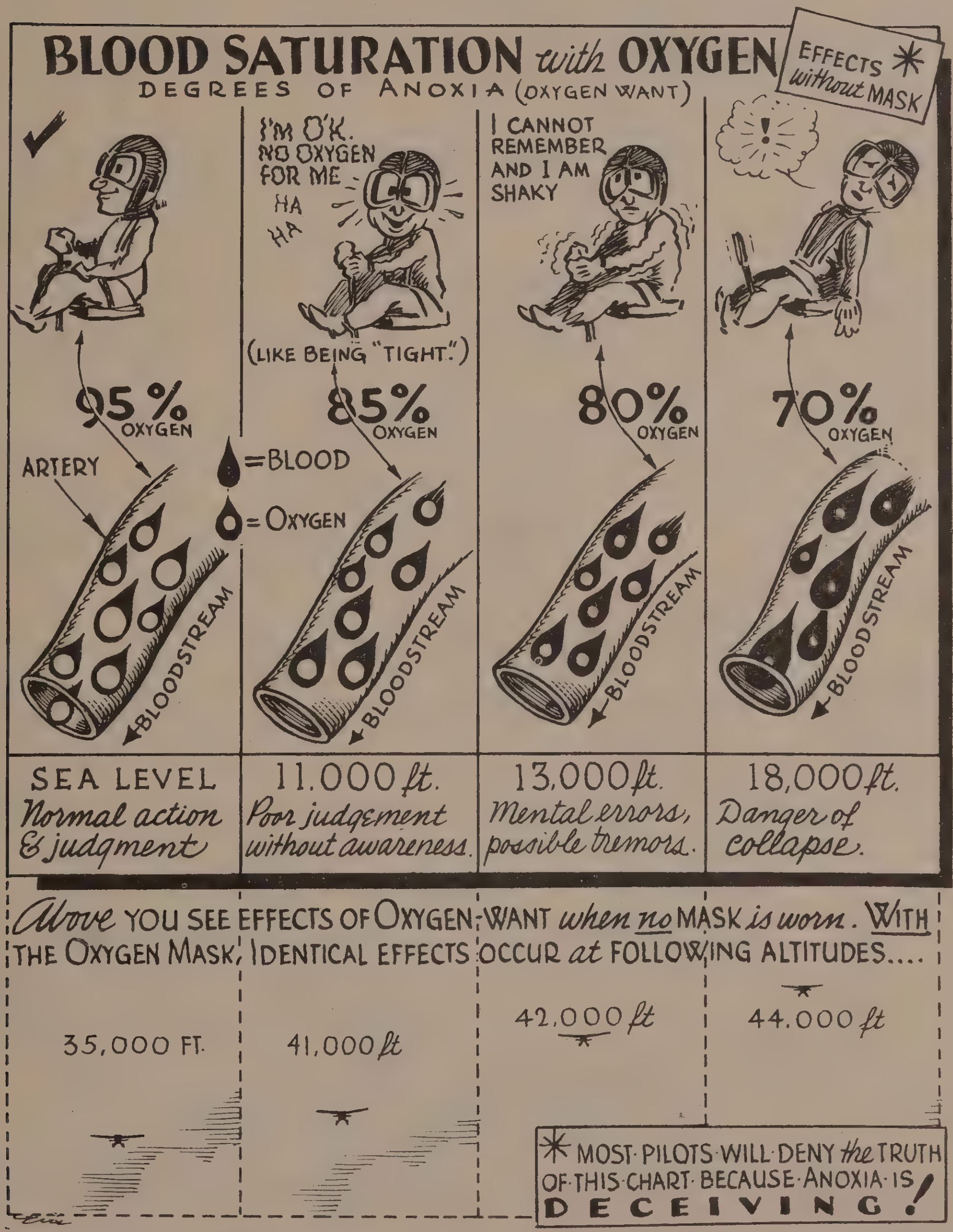
2. LOSS OF CAPACITY. - There are two ways in which the blood can lose its normal capacity to carry oxygen to the body. One is an anemia or a decrease of red blood cells. In flyers this is most likely to occur through loss of blood from injury. It is like grounding some of the planes on your airline. The others may continue to fly full loads on schedule but total deliveries are below the maximum desired. Second, red blood cells may lose their oxygen-carrying capacity. This occurs when some gas or drug, such as carbon monoxide or sulfanilamide, grabs the space normally occupied by oxygen. Carbon monoxide from the engine exhaust is especially dangerous because the red blood cells will absorb it 200 times more readily than they will absorb oxygen. The result is the same as if all your planes were flying their route on time and fully loaded, with sand. It's the pay load that counts.

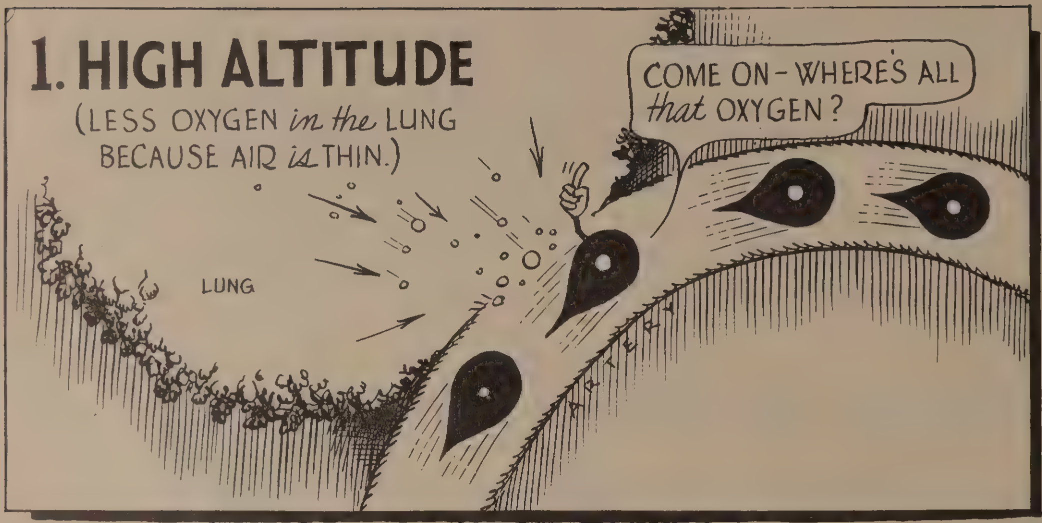
3. SLOW FLOW. - Fear, pain, injury, or, in general, shock may cause your blood pressure to drop far below normal. As a result the flow of blood carrying oxygen through the body slows down. This too, may result from loss of blood. Even without hemorrhage, severe shock calls for the continu-

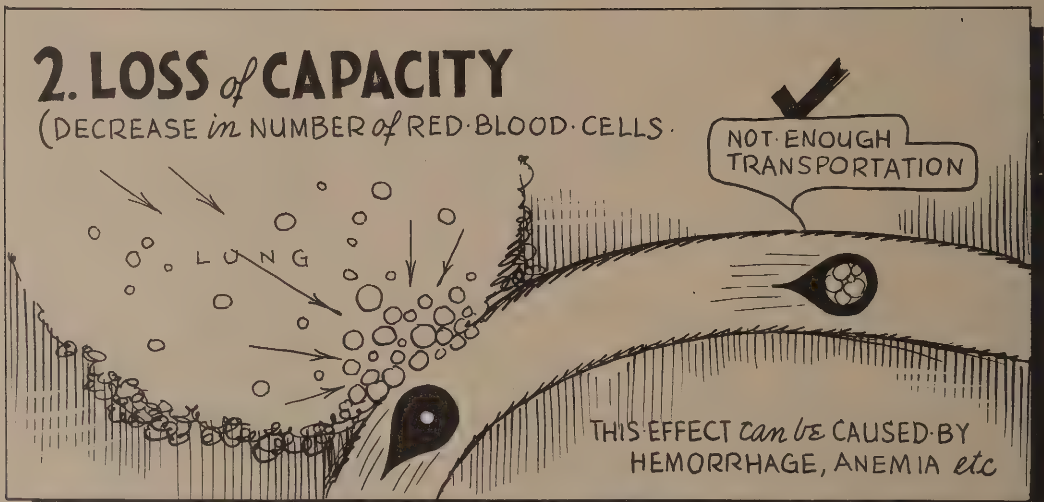
ous administration of oxygen whatever the altitude. The situation is simply that of a fleet of cargo planes carrying full loads but flying so slowly they get behind schedule.

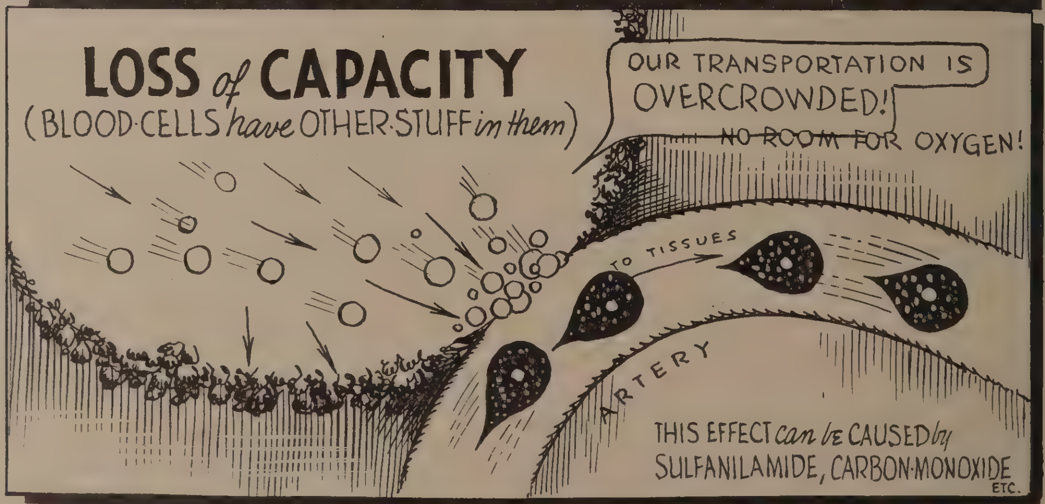
4. TISSUE POISONING. - Some drugs and gases, such as alcohol and its gas, cause a different kind of break-down in the oxygen supply system. They tend to block up the tissues so that the blood cannot unload its oxygen. Thus the oxygen merely is returned to the lungs. It would be as if your air freight line were carrying full pay loads on schedule but made a round trip without setting down.

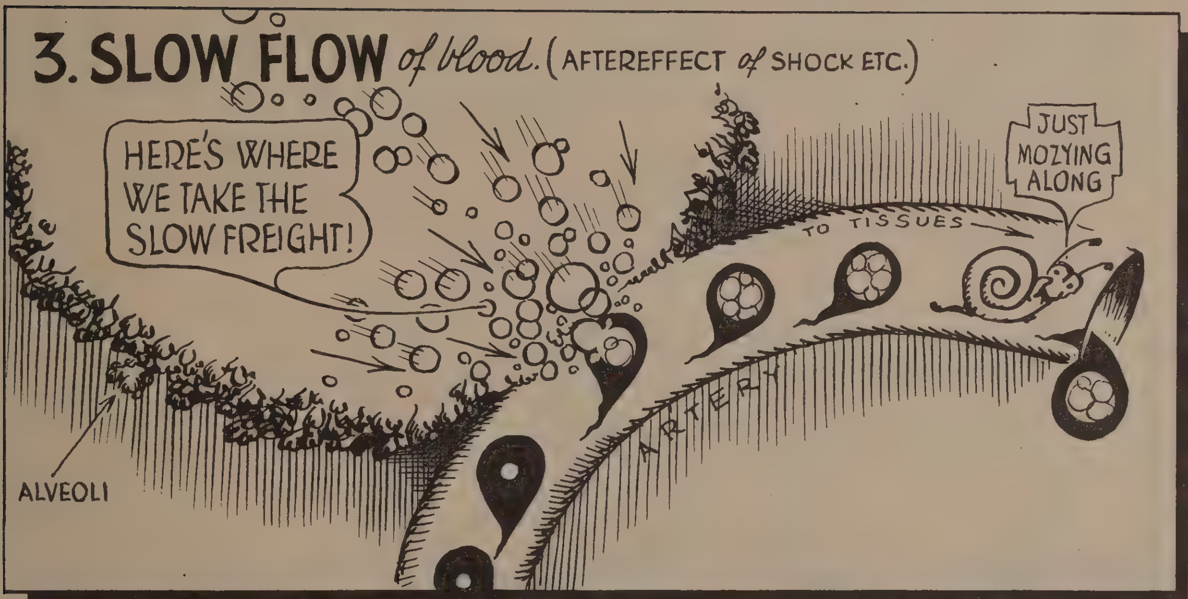
The following two pages depict these types of oxygen want.

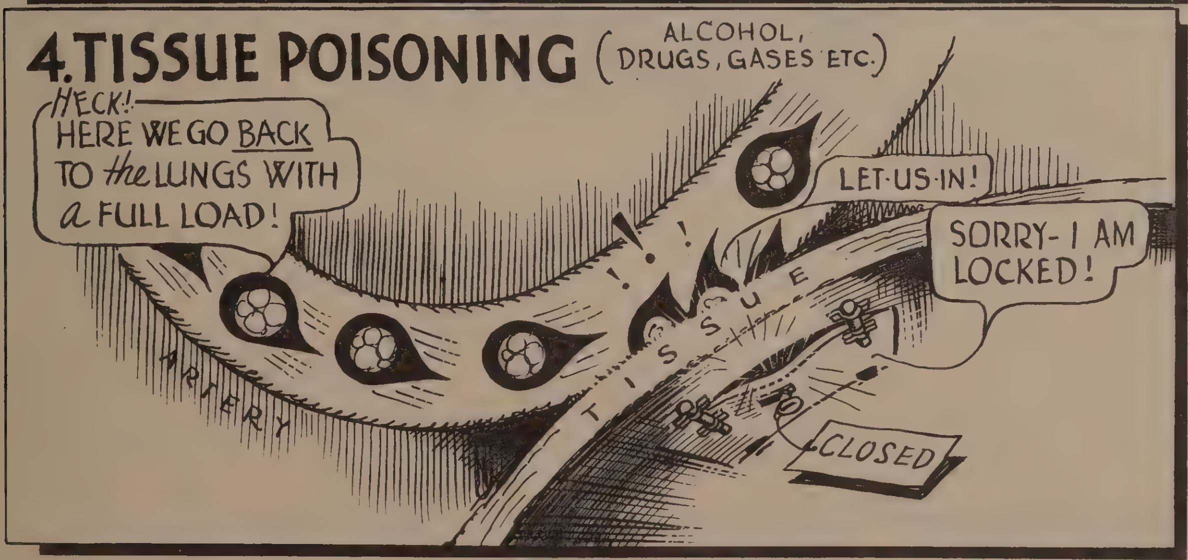



1. HIGH ALTITUDE
(LESS OXYGEN in the LUNG BECAUSE AIR is THIN.)
COME ON - WHERE'S ALL that OXYGEN?
LUNG
ARTERY


2. LOSS of CAPACITY
(DECREASE in NUMBER of RED·BLOOD·CELLS·
NOT·ENOUGH TRANSPORTATION
LUNG
THIS·EFFECT can be CAUSED·BY HEMORRHAGE, ANEMIA etc


LOSS of CAPACITY
(BLOOD·CELLS have OTHER·STUFF in them)
OUR TRANSPORTATION IS OVERCROWDED!
~~NO ROOM FOR~~ OXYGEN!
TO TISSUES
ARTERY
THIS EFFECT can be CAUSED by SULFANILAMIDE, CARBON·MONOXIDE ETC.


3. SLOW FLOW of blood. (AFTEREFFECT of SHOCK ETC.)
HERE'S WHERE WE TAKE THE SLOW FREIGHT!
JUST MOZYING ALONG
TO TISSUES
ARTERY
ALVEOLI


4. TISSUE POISONING (ALCOHOL, DRUGS, GASES ETC.)
HECK! HERE WE GO BACK TO the LUNGS WITH a FULL LOAD!
LET-US-IN!
SORRY- I AM LOCKED!
TISSUE
ARTERY
CLOSED

HOW TO AVOID OXYGEN WANT

A flyer's service ceiling is determined by the amount of oxygen getting into his blood. He cannot reach the ceiling, or stay there if he does reach it, when his oxygen pressure falls below a minimum.

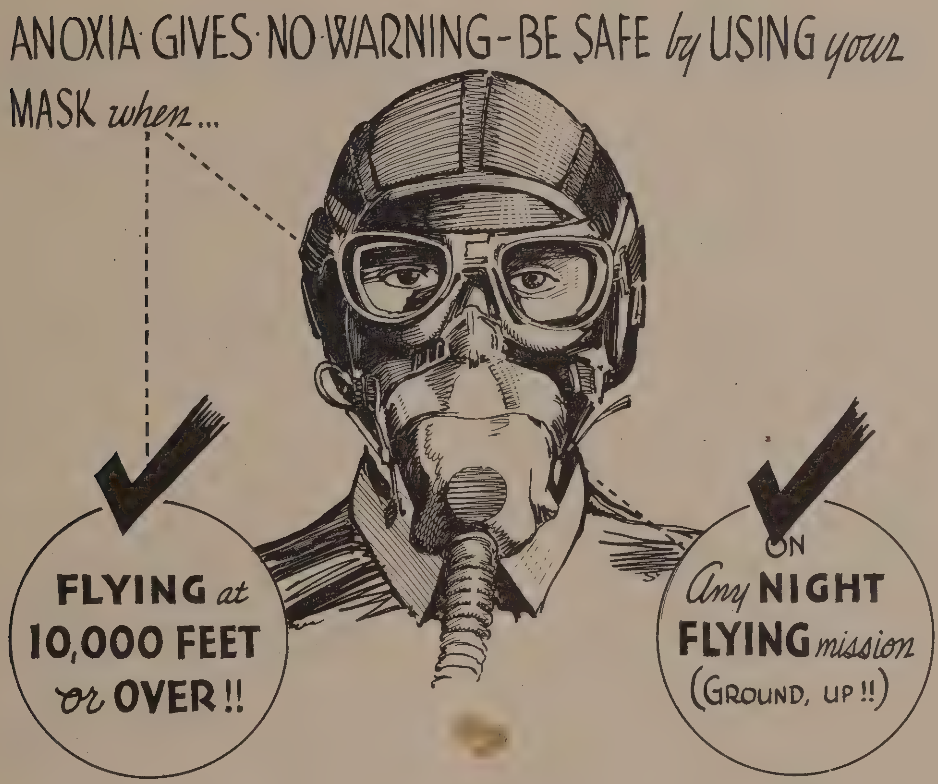
Unfortunately, he has no gage on his body to tell him when to put on his mask. He cannot depend on the way he feels to warn him. The time he needs to have his mask on is that treacherous moment when he may feel as happy as if he were drunk. Likewise, his mental judgment is no barometer, for at that moment it, too, may play tricks on him. The situation is made more difficult by the fact that some persons remain normal up to the time that they become unconscious; others will merely feel depressed. But there is no excuse for oxygen want to endanger you or your mission if you obey the rules:

USE OXYGEN AT ALL TIMES AT ALTITUDES OF 10,000 FEET AND HIGHER.

USE OXYGEN FROM THE GROUND UP ON ALL NIGHT FLYING MISSIONS.

All the flyer has to do is watch his altimeter and believe it when it reads 10,000 feet. He won't feel the need at this height, but it is a matter of habit; in fact, military discipline, for a good soldier to be prepared.

To be sure, a little anoxia won't hurt anyone in itself. A man about to pass out from it may completely recover within 15 seconds if his oxygen supply is brought back to normal. Bodily damage from oxygen want is rare, if you recover! But it kills quickly once you become unconscious. The damage if this occurs has tragic finality.



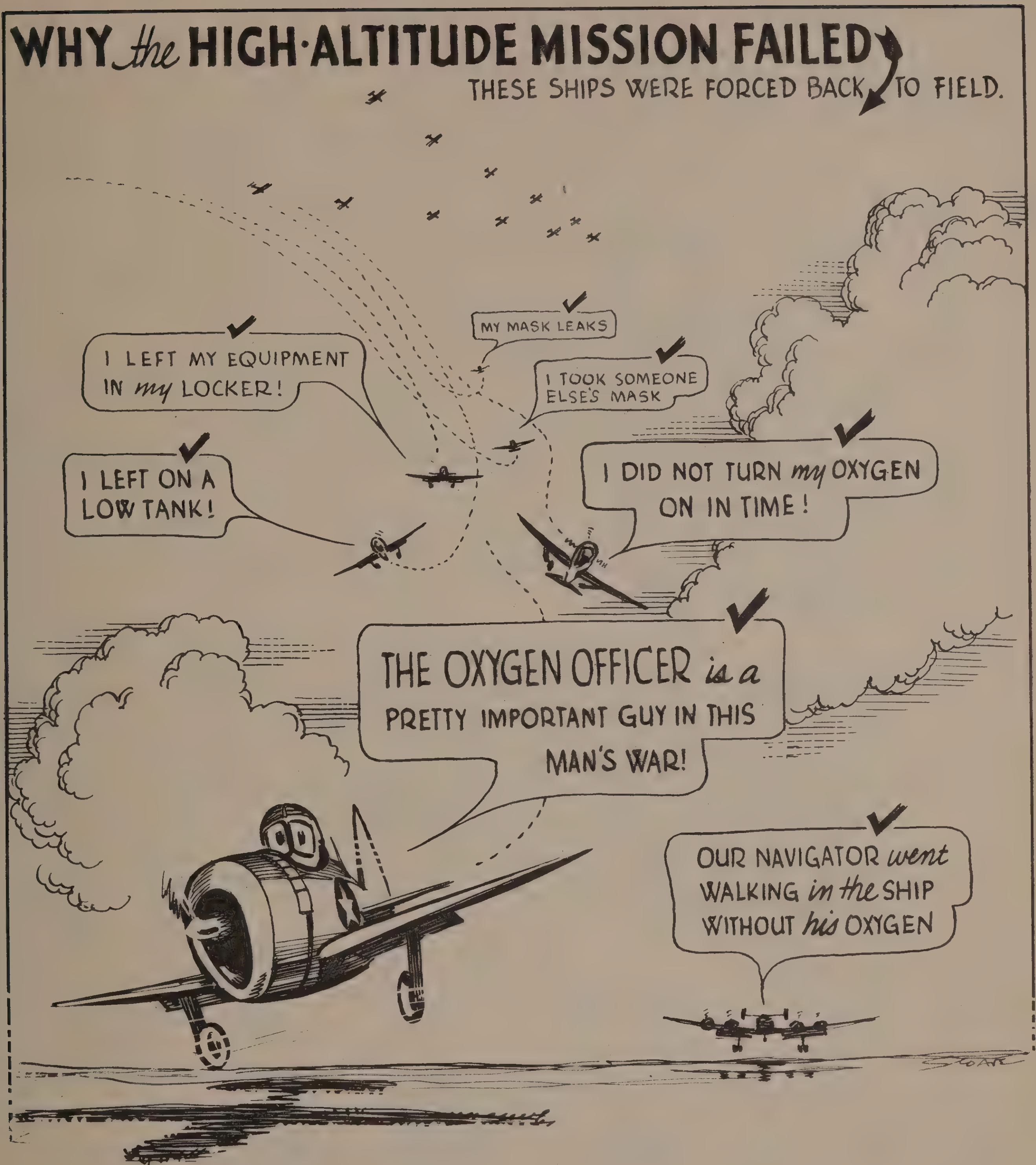
THE OXYGEN OFFICER

Existing oxygen systems have raised your ceiling from 18,000 feet to 40,000 feet. As long as your oxygen equipment functions correctly there is no danger at these altitudes. The correct functioning of that equipment is the responsibility of the Oxygen Officer.

The Oxygen Officer is especially trained in the use of the Air Forces' oxygen systems. He is kept up-to-date on changes in regulations and new developments. It is up to him to pass all essential information along to you.

To make sure your equipment is in working order, the Oxygen Officer is provided with special kits. One of them, for example, checks your mask against leakage. A good fit is important in this respect, and he will try to give you one. He will make a regular check to see if adjustments are needed to maintain this fit.

But when the plane takes off, the Oxygen Officer stays behind. You are on your own. Then the flyer must know for himself. Many a mission fails because the flyer didn't listen to the Oxygen Officer.

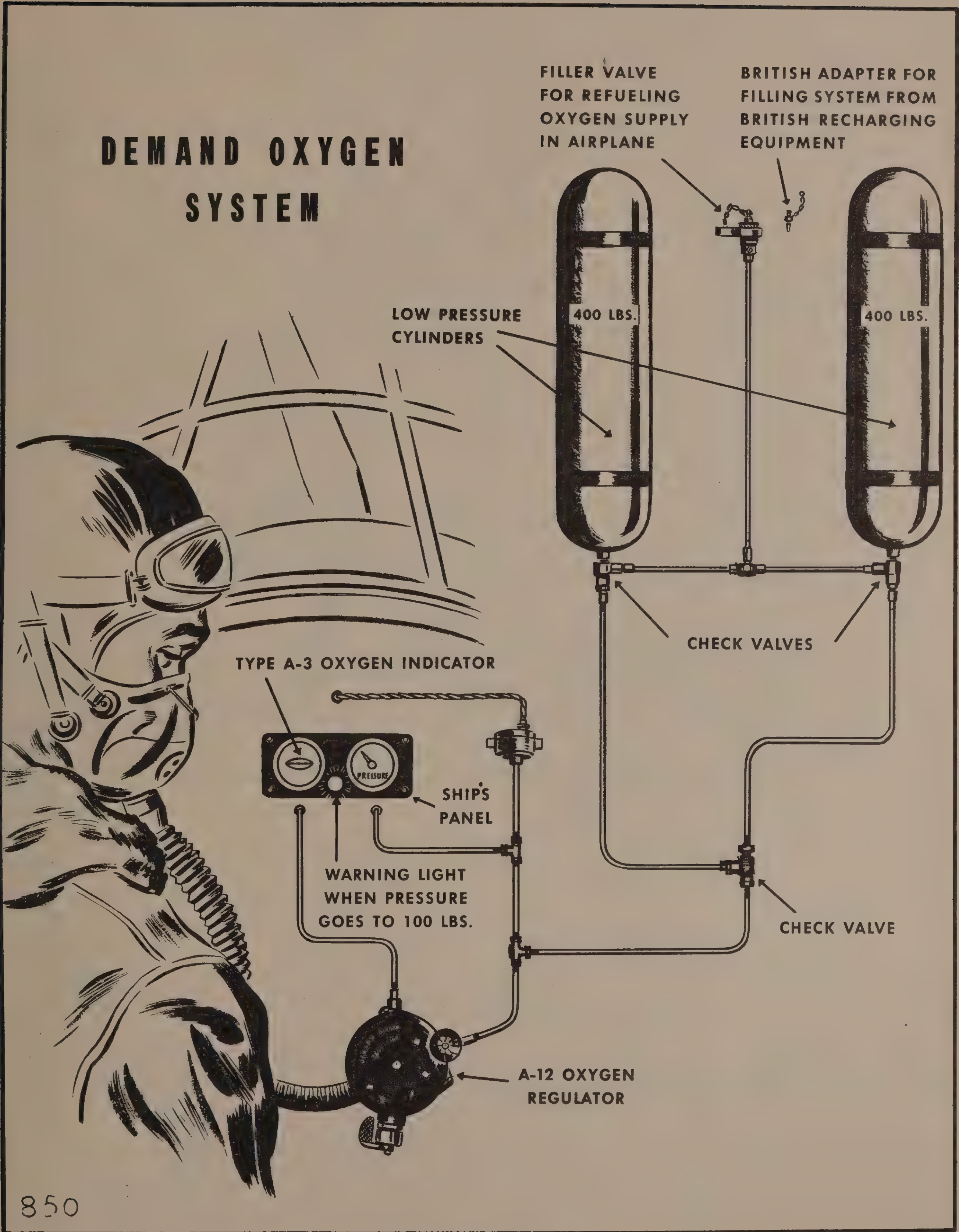

WHY the HIGH-ALTITUDE MISSION FAILED
THESE SHIPS WERE FORCED BACK TO FIELD.
MY MASK LEAKS
I LEFT MY EQUIPMENT IN my LOCKER!
I TOOK SOMEONE ELSE'S MASK
I LEFT ON A LOW TANK!
I DID NOT TURN my OXYGEN ON IN TIME!
THE OXYGEN OFFICER is a PRETTY IMPORTANT GUY IN THIS MAN'S WAR!
OUR NAVIGATOR went WALKING in the SHIP WITHOUT his OXYGEN

THE DEMAND OXYGEN SYSTEM

Our planes are equipped with either of two types of oxygen "plumbing:" (1) The demand system, and (2) The continuous flow system.

The demand system is fully automatic, and supplies oxygen according to the demand for it. Its flow regulator contains a valve which opens and lets oxygen pass through a tube to the mask when the flyer inhales; when suction ceases, the valve closes. The regulator has a tiny bellows which responds to atmospheric pressure. It is attached to a valve which permits ordinary air to flow into the mask at sea level, where no additional oxygen is needed. As altitude increases, the bellows closes the air valve and opens an oxygen valve, thus changing the proportions of air and oxygen to meet the need. Finally, at 30,000 feet, all air from the outside is shut off and the regulator supplies the flyer with 100 percent oxygen. The demand system has two great virtues: It gives a man all the oxygen he needs, whether he is breathing fast or slow; yet it doesn't waste oxygen, which becomes precious when operations are dependent upon how long it will last.

The station of each flyer in a bomber is equipped with a regulator and a series of oxygen cylinders piped together. In this respect, the system resembles that in a one-place pursuit plane. In a bomber, however, the cylinders at each station are connected with those at all other stations for two purposes: (1) So that the entire system can be refilled through one intake. (2) So that an interchange of pressure may take place between stations should one individual, such as a hard-working gunner, consume more than the others. Each cylinder is independent of all others to the extent that if it is shattered by gunfire, the sudden release of pressure causes a check valve to cut it off from the rest of the cirucit, thus conserving the remainder of the oxygen supply. If all cylinders at one station are shot up, the man there must rely on a portable oxygen unit. The cylinders are shatterproof and under low pressure (425 pounds per square inch) so that a bullet's impact will not cause an explosion.


DEMAND OXYGEN SYSTEM
FILLER VALVE FOR REFUELING OXYGEN SUPPLY IN AIRPLANE
BRITISH ADAPTER FOR FILLING SYSTEM FROM BRITISH RECHARGING EQUIPMENT
LOW PRESSURE CYLINDERS
400 LBS.
400 LBS.
CHECK VALVES
TYPE A-3 OXYGEN INDICATOR
PRESSURE
SHIP'S PANEL
WARNING LIGHT WHEN PRESSURE GOES TO 100 LBS.
CHECK VALVE
A-12 OXYGEN REGULATOR
850

THE AUTO-MIX

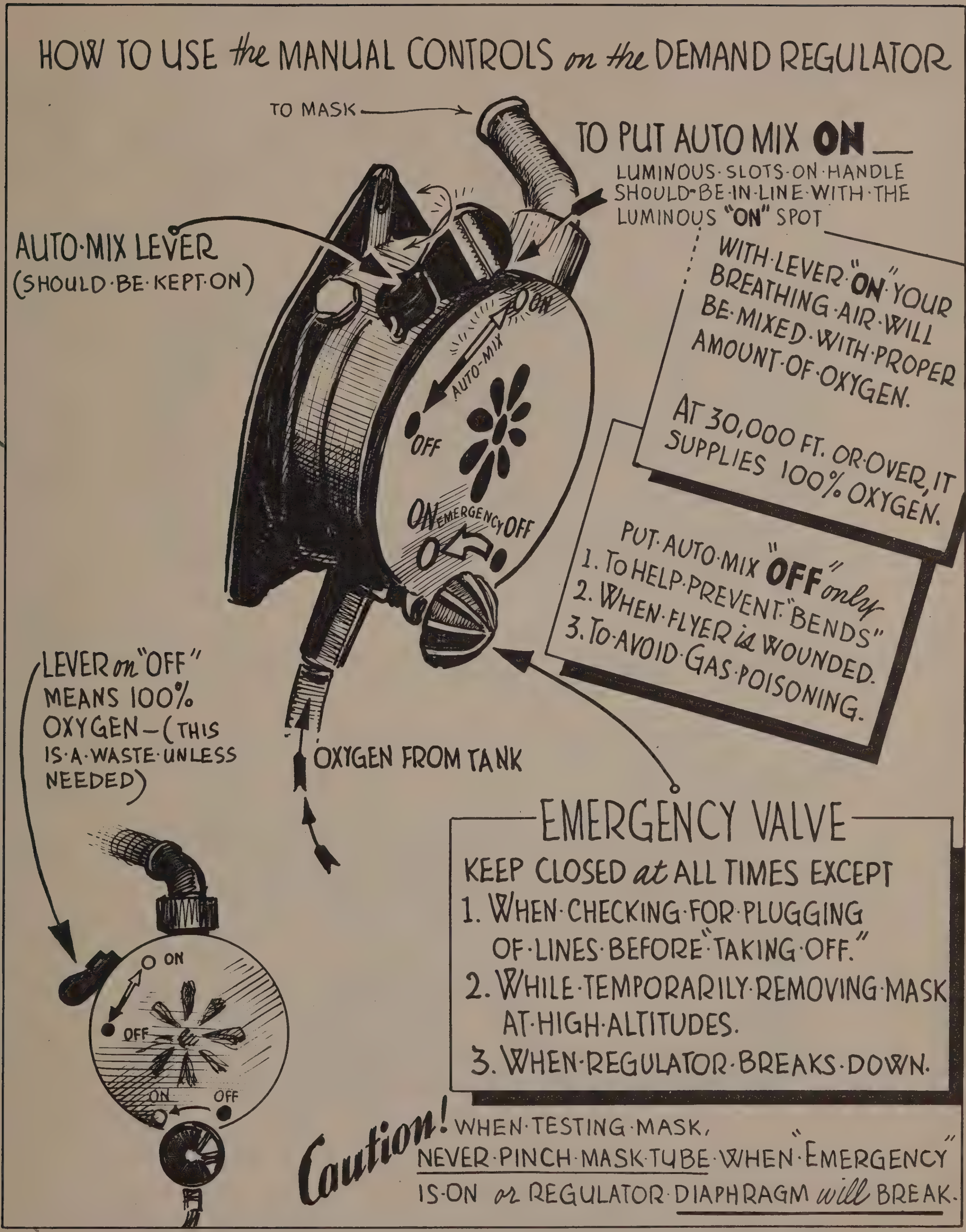
While the demand oxygen system is fully automatic, the regulator has two manual controls for special use. The flyer must understand their use without question.

One control, a lever, is labeled "AUTO-MIX." This means the automatic mixing of oxygen with air. The lever may be turned "ON" or "OFF." "ON" means that the automatic system is in operation to supply a proper mixture of oxygen and air at all altitudes. "OFF" means that the air port is closed so that the flyer will get pure oxygen at all altitudes. The flyer must remember that "ON" does not mean straight oxygen and "OFF" does not mean that the system has been turned off. When the auto-mix is on, as it should be under ordinary circumstances, the luminous spot on the lever lines up with a luminous spot on the regulator below the word "ON." When it is off, the spot on the lever is hidden.

The auto-mix is turned off in only three cases: (1) When the flight surgeon requests the flyer to rid his system of nitrogen by breathing pure oxygen to avoid bends on high-altitude flights. (2) When a flyer is sick or wounded and the demand system is not furnishing 100 percent oxygen; that is, below 30,000 feet. (3) When exhaust fumes or poison gas endanger the flyer.

The second control on the regulator is the emergency valve. When screwed open, the emergency valve creates a bypass around the regulator permitting pure oxygen to rush into the tube to the mask. It is opened only (1) before flight to check for any plugging of the lines, (2) when the mask is temporarily loosened or removed at high altitudes, and (3) when the regulator breaks down and fails to supply oxygen on demand. It is extremely wasteful to open this valve at any other time.

OXYGEN IS THE BREATH OF LIFE. DO NOT WASTE YOUR BREATH!

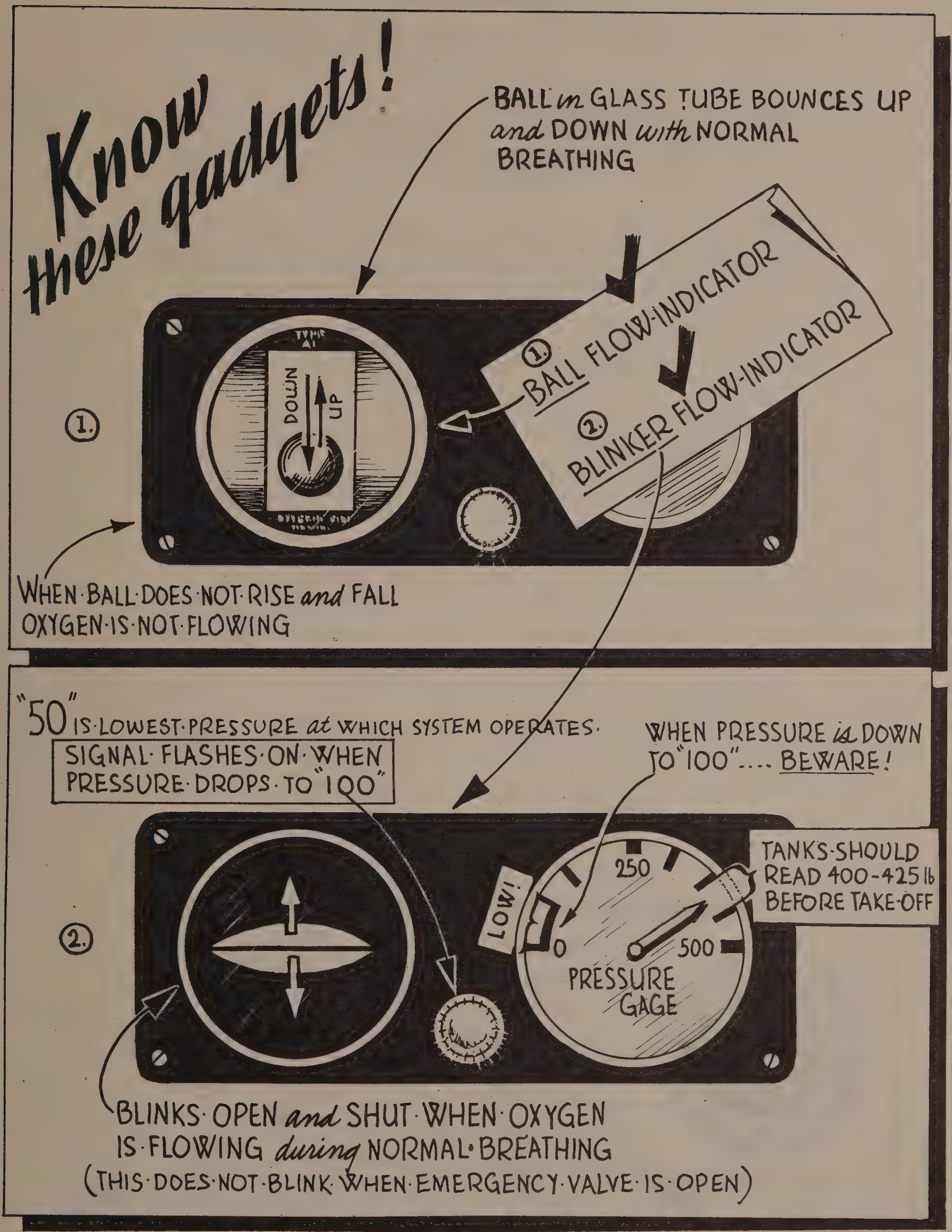

HOW TO USE the MANUAL CONTROLS on the DEMAND REGULATOR
TO MASK
TO PUT AUTO MIX ON —
LUMINOUS·SLOTS·ON·HANDLE SHOULD·BE·IN·LINE·WITH·THE LUMINOUS "ON" SPOT
AUTO·MIX LEVER (SHOULD·BE·KEPT·ON)
WITH·LEVER "ON" YOUR BREATHING·AIR·WILL BE·MIXED·WITH·PROPER AMOUNT·OF·OXYGEN.
AT 30,000 FT. OR·OVER, IT SUPPLIES 100% OXYGEN.
ON
AUTO-MIX
OFF
ON EMERGENCY OFF
PUT·AUTO·MIX "OFF" only
1. TO HELP·PREVENT "BENDS"
2. WHEN·FLYER is WOUNDED.
3. TO·AVOID·GAS·POISONING.
LEVER on "OFF" MEANS 100% OXYGEN—(THIS IS·A·WASTE·UNLESS NEEDED)
OXYGEN FROM TANK
EMERGENCY VALVE
KEEP CLOSED at ALL TIMES EXCEPT
1. WHEN·CHECKING·FOR·PLUGGING OF·LINES·BEFORE "TAKING·OFF."
2. WHILE·TEMPORARILY·REMOVING·MASK AT·HIGH·ALTITUDES.
3. WHEN·REGULATOR·BREAKS·DOWN.
O ON
OFF
ON
OFF
Caution! WHEN·TESTING·MASK, NEVER·PINCH·MASK·TUBE·WHEN "EMERGENCY" IS·ON or REGULATOR·DIAPHRAGM will BREAK.

FLOW AND PRESSURE SIGNALS

The flow indicator, mounted near the regulator, tells the flyer whether or not oxygen is moving through the system. The indicator may be (1) a transparent tube containing a ball (type A-1) which rises when oxygen is flowing and falls when it is not or (2) a blinker (type A-3) which opens when oxygen is flowing and closes when it stops. Normal breathing through the mask causes the blinker to wink like an eye and the ball to bounce up and down. The blinker will not work when the emergency valve is on, but the ball will. Some regulators will show flow at ground level and others will not. In either case, there is no need for concern.

The pressure gage and signal lamp are mounted on a panel with the flow indicator in a single-place plane or separately in a multi-place ship. The pressure gage tells you the oxygen supply you have. From it, you can estimate how long you can last at critical altitudes. There is one exception: If your plane has been badly shot up, the pressure gage will not show you if any of the cylinders have been knocked out. The total pressure is always the same no matter how many cylinders you draw from.

Filled to capacity, the cylinders have a pressure of 425 pounds per square inch. You should never begin a flight with the pressure less than 400. When the pressure drops to 100 pounds per square inch while you are in flight, it is time to think about going down. At this point the signal light flashes on to warn you that your supply is running low. Fifty is the lowest pressure at which the demand type regulator will furnish you oxygen with safety. Ordinarily, you should be down to 10,000 feet by that time. In emergencies, however, you can stay up a little longer by turning on the emergency valve and using up what is left in your oxygen cylinders. This gives you 100 percent oxygen but it won't last long.


Know these gadgets!
BALL in GLASS TUBE BOUNCES UP and DOWN with NORMAL BREATHING
1. BALL FLOW-INDICATOR
2. BLINKER FLOW-INDICATOR
1.
DOWN
UP
WHEN BALL DOES NOT RISE and FALL OXYGEN IS NOT FLOWING
"50" IS LOWEST PRESSURE at WHICH SYSTEM OPERATES.
SIGNAL FLASHES ON WHEN PRESSURE DROPS TO "100"
WHEN PRESSURE is DOWN TO "100".... BEWARE!
TANKS SHOULD READ 400-425 lb BEFORE TAKE-OFF
2.
LOW!
250
0
500
PRESSURE GAGE
BLINKS OPEN and SHUT WHEN OXYGEN IS FLOWING during NORMAL BREATHING
(THIS DOES NOT BLINK WHEN EMERGENCY VALVE IS OPEN)

DEMAND MASK

The demand oxygen system requires a special mask, and the most important thing for the flyer to know about it is that it should fit tightly, yet comfortably.

A misfit will permit outside air to leak in. This is extremely dangerous at altitudes of 30,000 feet and up. It is undesirable to have accidental dilutions of the mixture provided by the regulator at any altitude. Decreasing density of the air causes small leaks to become larger, and may cause oxygen want at critical heights.

Fitting is the job of the oxygen officer. He has a testing machine to determine accurately whether your mask leaks. He will fit your mask in the first place. Natural stretch in the straps may require future adjustment, and if you have to change the fit, have him check it at the first opportunity.

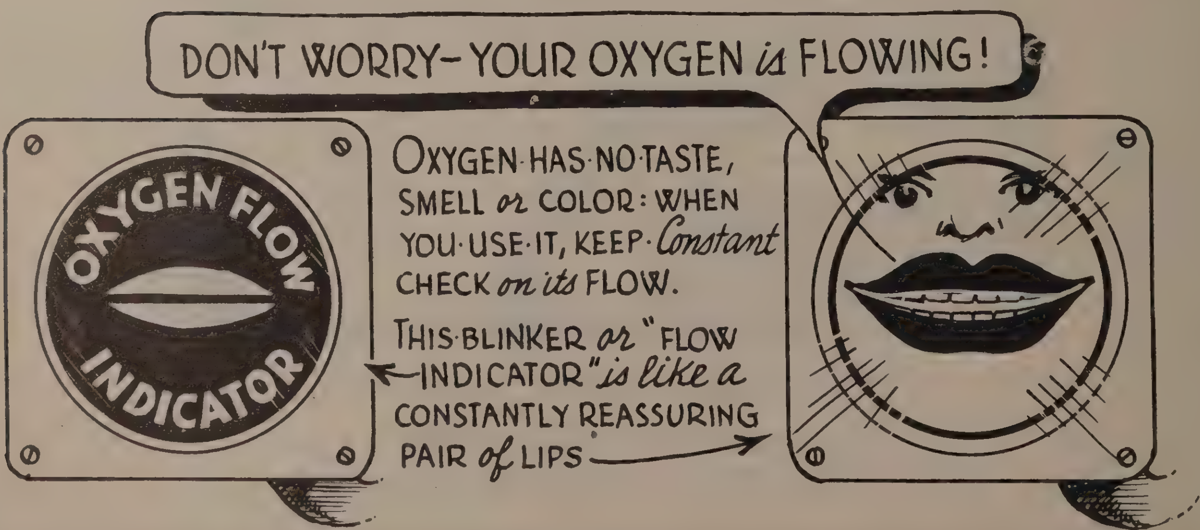
Before taking off, you should make a quick test for leaks by holding your thumb over the end of the supply hose and inhaling gently. If in good order, the mask will press against your face and prevent you from getting air. While you are flying it may be necessary to manipulate the mask to free it of ice formation or to remove it temporarily when blowing your nose or in case of vomiting. In these circumstances, the emergency valve should be turned on to provide an extra supply of oxygen under pressure to offset the thin, outside air you will breathe. When replaced the mask should be tested for leakage as just described, the hose in this case being held closed with your hand. BUT NEVER DO THIS WHILE THE EMERGENCY VALVE IS OPEN BECAUSE THE BACK PRESSURE WILL BLOW OUT THE DIAPHRAGM IN THE REGULATOR.

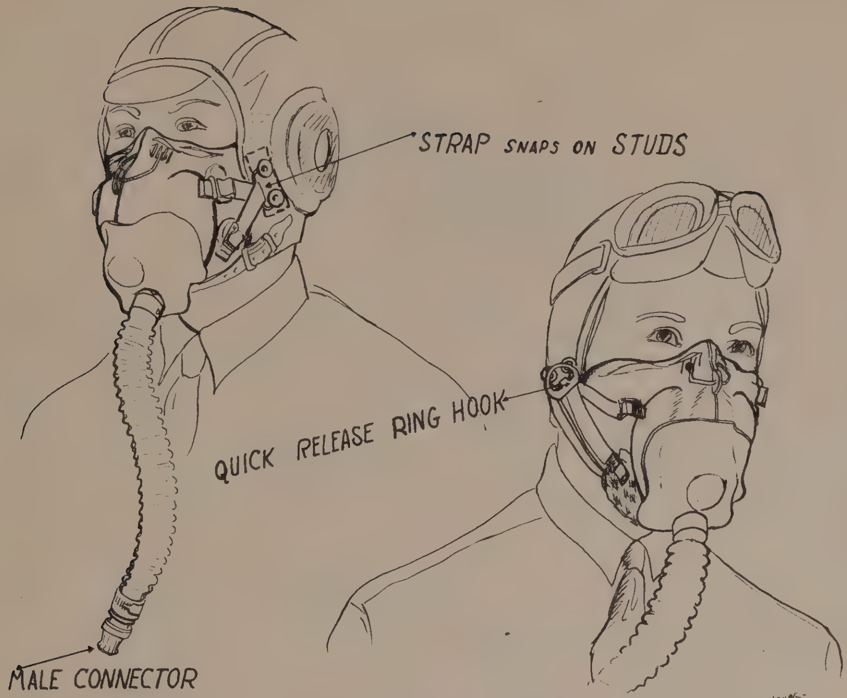
Almost all demand masks in current use are of two types. An older style (A-10), which comes in three sizes, has a head harness easily identified by the strap extending upward from the nose. The newer type (A-10 revised), in four sizes, has a simplified harness which hooks to the helmet. In both types, a flapper valve discharges waste gases when you exhale and remains closed when you inhale.

In addition to the instructions on fitting, there are some other things you should remember about your mask:

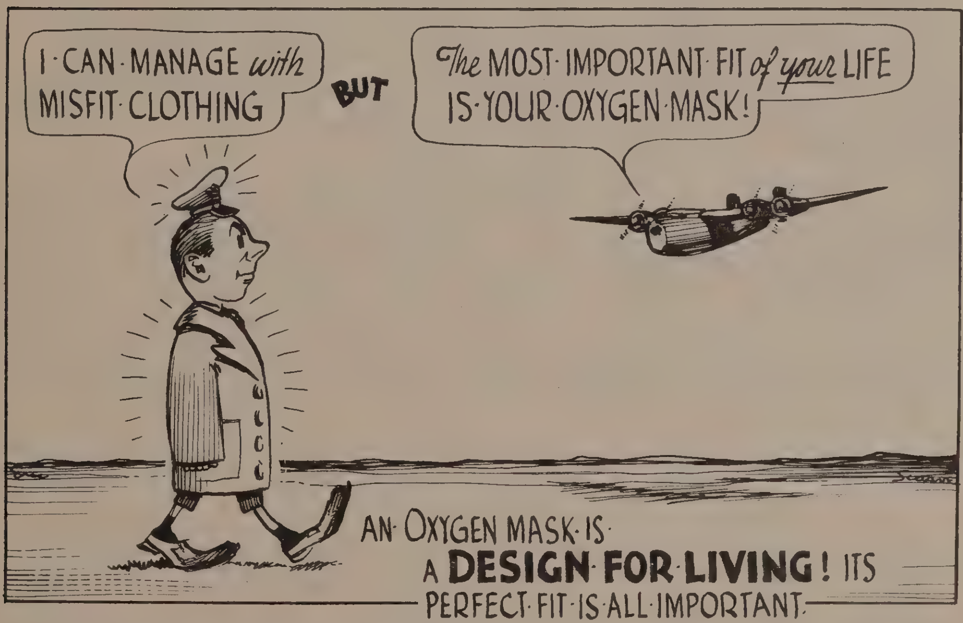
One is that it should never be lent to anyone else. It may not fit the borrower, leaves you without one, and is a good way to spread a cold.

It should be inspected regularly for cracks or other damage.





A-10 REVISED MASK



It should be wiped dry when you return from a flight, and occasionally washed with soap and water. Be careful, however, not to wet the microphone.

When you "plug in" your mask, make certain that the rubber gasket is in place in the end of the male connector. And be sure that a snug connection is made with the outlet from the regulator.

The spring clip on the supply hose should be fastened to your clothing or parachute harness close enough to the face so that the head may be turned freely without kinking or pulling the hose.

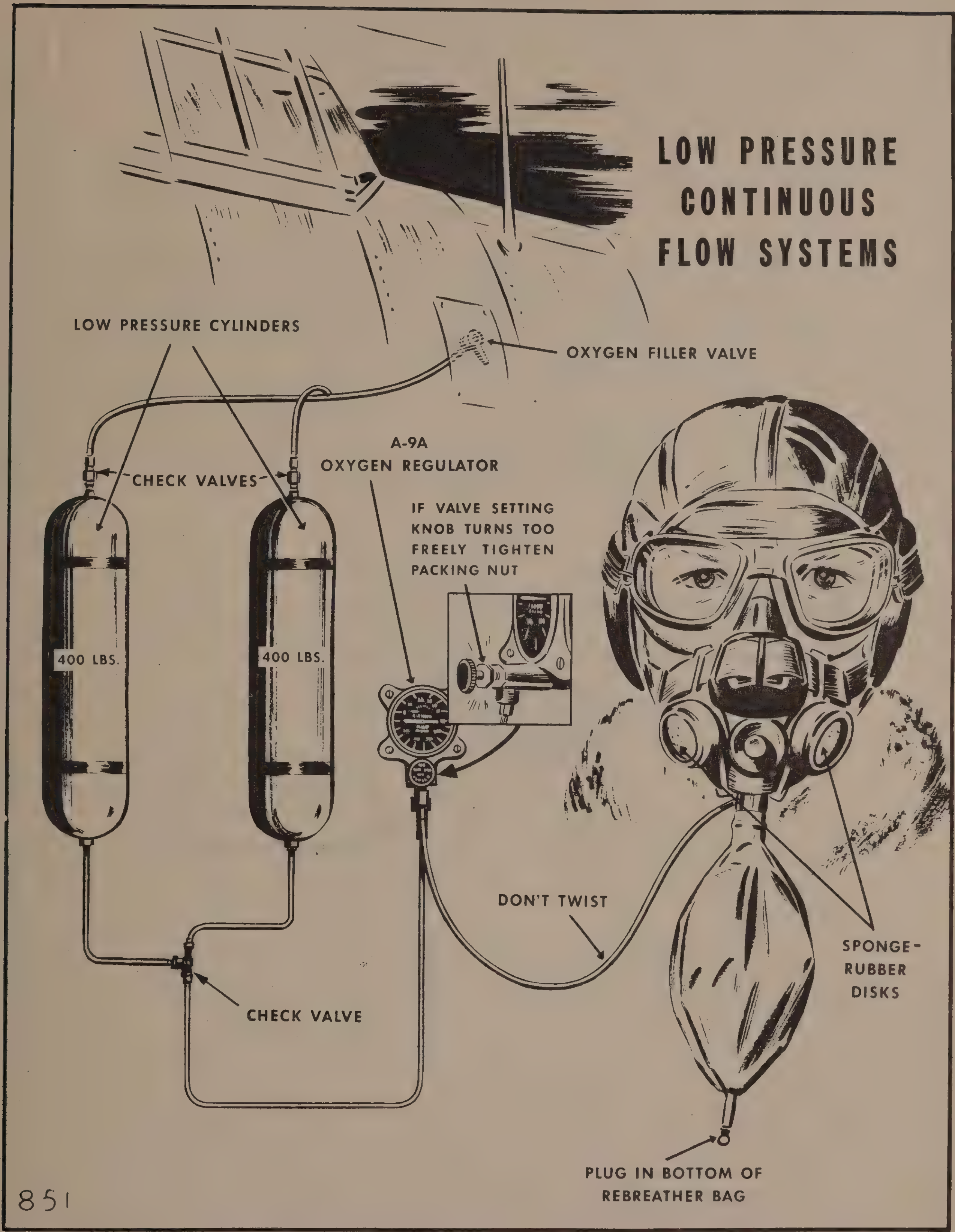
THE CONTINUOUS FLOW OXYGEN SYSTEM

The second type of aircraft oxygen installation is the continuous flow system. It has been replaced by the demand type in planes in current production, but still exists in the older aircraft. The flow of oxygen is continuous while the system is in use. The flyer must adjust the amount of oxygen being mixed with the air to correspond with the altitude. This is done by turning a regulator valve which registers on a flow indicator dial mounted on the regulator. The flow indicator is graduated in 1000's of feet and the reading should be set to approximate the reading on the altimeter. The lower half of the dial contains a pressure gage, which works the same as that in the demand type.

Two types of masks are used with the continuous flow system; the A-8 and A-8B. The first has one turret in front of the mouth and the latter, two. The turrets contain sponge rubber disks, through which air to be mixed with the oxygen is admitted at low altitudes. This does not occur when the regulator valve is opened all the way at altitudes above 30,000 feet.

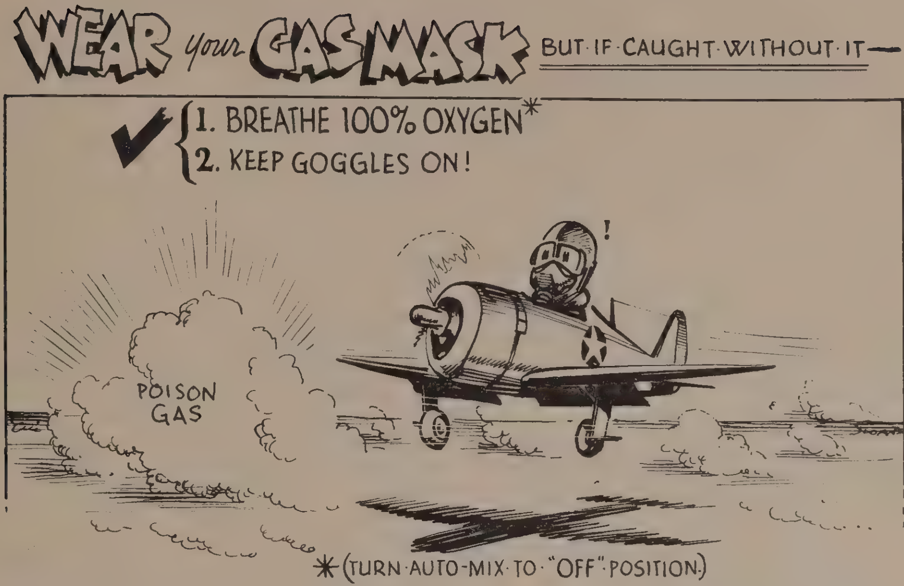
These continuous flow type masks have a flexible rubber rebreather bag hanging below the mask and connecting at the top with the oxygen intake. At each inspiration, the flyer breathes the contents of the bag. Furthermore, he exhales part of his breath into the bag. This does not mean that he is breathing stale air inasmuch as the oxygen content of the last part of each breath remains unchanged. It comes out first and fills the bag. This saves oxygen which otherwise would be wasted in exhaling. The waste portion of the breath goes out through the turrets.

It is important that the rebreather bag should never completely collapse at altitudes above 30,000 feet, since this will cause air to be taken in through the turrets. If it should collapse, turn open the regulator valve until it ceases to do so. The valve knob should not be allowed to loosen to a point where the brush of a sleeve will change the setting. Tightening of the packing nut will correct this. Ice should be kept out of the mask turrets. As a safeguard against a freeze-up an extra mask should be carried, especially by flyers in the waist and tail of a bomber. Otherwise, the care of the mask and equipment is much the same as that for the demand type described on pages 36, 37.


LOW PRESSURE CONTINUOUS FLOW SYSTEMS
LOW PRESSURE CYLINDERS
OXYGEN FILLER VALVE
CHECK VALVES
A-9A OXYGEN REGULATOR
IF VALVE SETTING KNOB TURNS TOO FREELY TIGHTEN PACKING NUT
400 LBS.
400 LBS.
DON'T TWIST
SPONGE-RUBBER DISKS
CHECK VALVE
PLUG IN BOTTOM OF REBREATHER BAG
851

OXYGEN, OIL, AND SUDDEN DEATH

Here is a note of caution you ought to paste on your oil can: DO NOT PERMIT OIL OR GREASE TO GET ON ANY OXYGEN EQUIPMENT. This includes all lines, fittings, instruments, and your mask (oil rots rubber). Oxygen is the source of all combustion and even slight traces of oil or grease coming in contact with it under pressure may produce a fire or explosion. NEVER USE ANY LUBRICANTS IN THE OXYGEN SYSTEM.



POISON GAS VS. OXYGEN

You have a great deal of paraphernalia to carry every time you go into the air. You are likely to consider your gas mask as excess baggage. Don't make this mistake. Take it with you in combat theaters. The first gas attacks will come by surprise.

You will return some day to see clouds of smoke rising over the field, without any sign of fire or bomb craters. You will realize that the enemy has dropped gas and, if you can, you will fly to another field. But the chances are that should you be returning from a mission, you will be short on gasoline and obliged to land. You will have your gas mask!

Fortunately, if you don't have it and you are caught off guard, your oxygen mask and goggles will serve as a stoppage gas mask. Both should fit tightly. You prepare the demand oxygen mask for gas defense by switching the automix to the "OFF" position, which gives you 100 percent oxygen. With the continuous flow type, turn the regulator valve all the way open.

Your oxygen mask is good, of course, only if you stay in your plane and only as long as your oxygen supply holds out. You should signal someone on the ground to bring you a regular gas mask. Otherwise you can't get out with safety until the gas has cleared.

THE WALK-AROUND BOTTLE

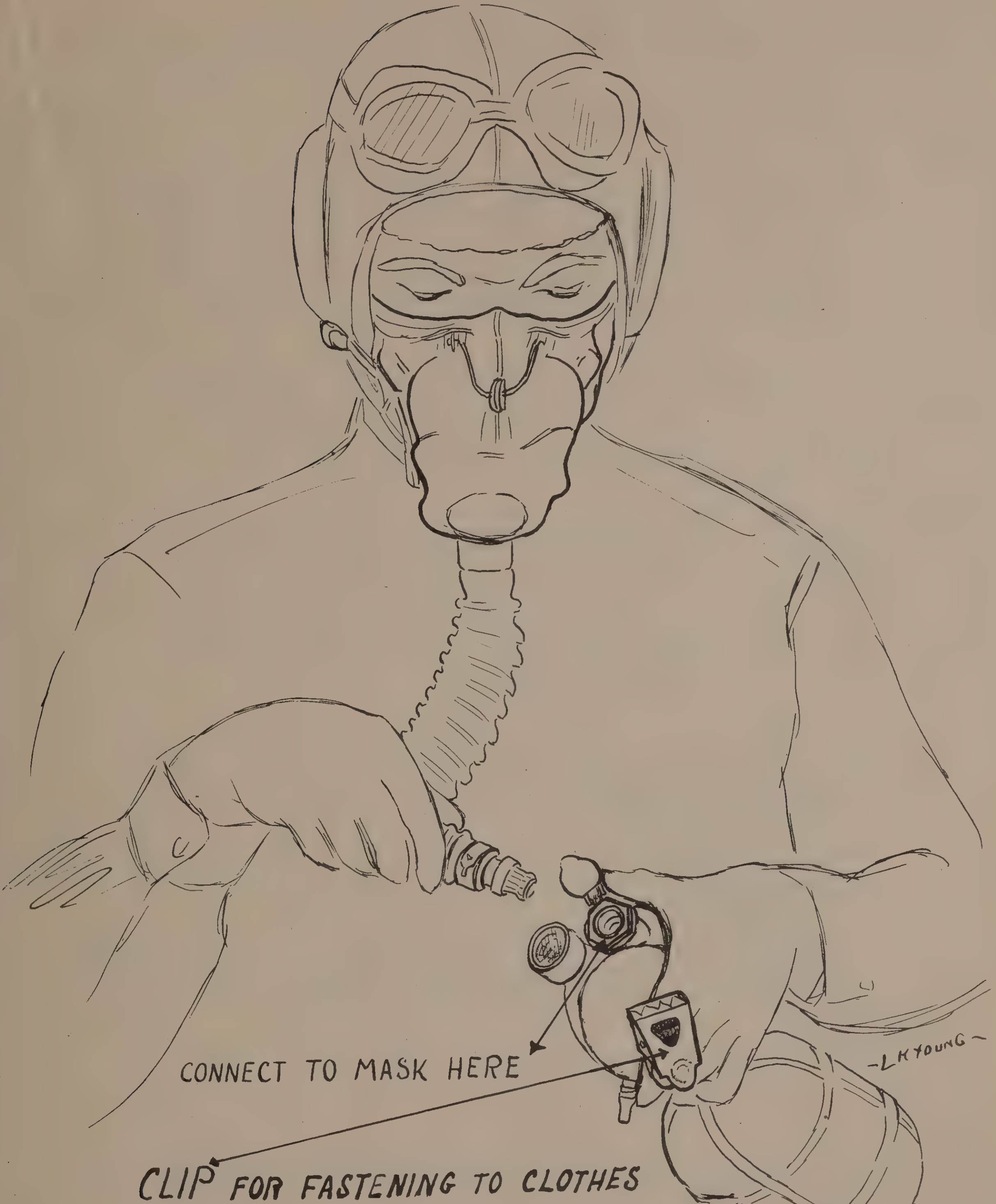
In large bombing planes it is often necessary for men to move about during flight to perform their duties or to go to the assistance of another member of the crew. Portable oxygen units called walk-around bottles, supply them with oxygen during periods away from their stations.

The walk-around bottle consists of a small oxygen cylinder which fastens to the clothing and attaches to the flyer's own oxygen mask. It comes in both demand and continuous flow types.

The demand type furnishes pure oxygen only, and has a 4- to 8-minute supply, depending on the altitude and activity of the user. However the bottle can be filled from the airplane's oxygen system by means of a portable filling hose. A regulator on the bottle shows the amount of pressure. The cylinder should be kept fully charged at all times for emergency use.

The continuous flow, walk-around bottle is sufficient to provide oxygen for about 1 hour at an altitude of 30,000 feet. It cannot be recharged in the plane.

To use either type of walk-around bottle, the flyer holds his breath while disconnecting his mask from the plane's oxygen system and then connects the mask directly to the portable unit's regulator.



WALK AROUND BOTTLE

USE OF OXYGEN IN PARACHUTE JUMPS

The possibility of having to bail out and join the Caterpillar Club is something every flyer must be prepared for. Swinging to earth on a piece of ballooning silk is dangerous enough without addition of other perils which may be encountered in descent. These include (1) fouling your parachute on the plane by pulling the rip cord too soon, (2) an initial falling speed too great for your chute to withstand, (3) unconsciousness from oxygen want at altitudes over 30,000 feet, (4) freezing while floating through subzero temperatures found at these altitudes, and (5) strafing from enemy planes.

All of these perils may be minimized greatly by use of the <u>free fall</u> to a low altitude before opening the parachute. The longer you delay opening the chute, the less time you are exposed to high-altitude hazards. From 40,000 feet, a parachute descent takes 24-1/2 minutes, whereas a free fall requires a trifle over 3 minutes. You fall the first 10,000 feet, where oxygen want and freezing are most dangerous, in just over 1/2 minute.

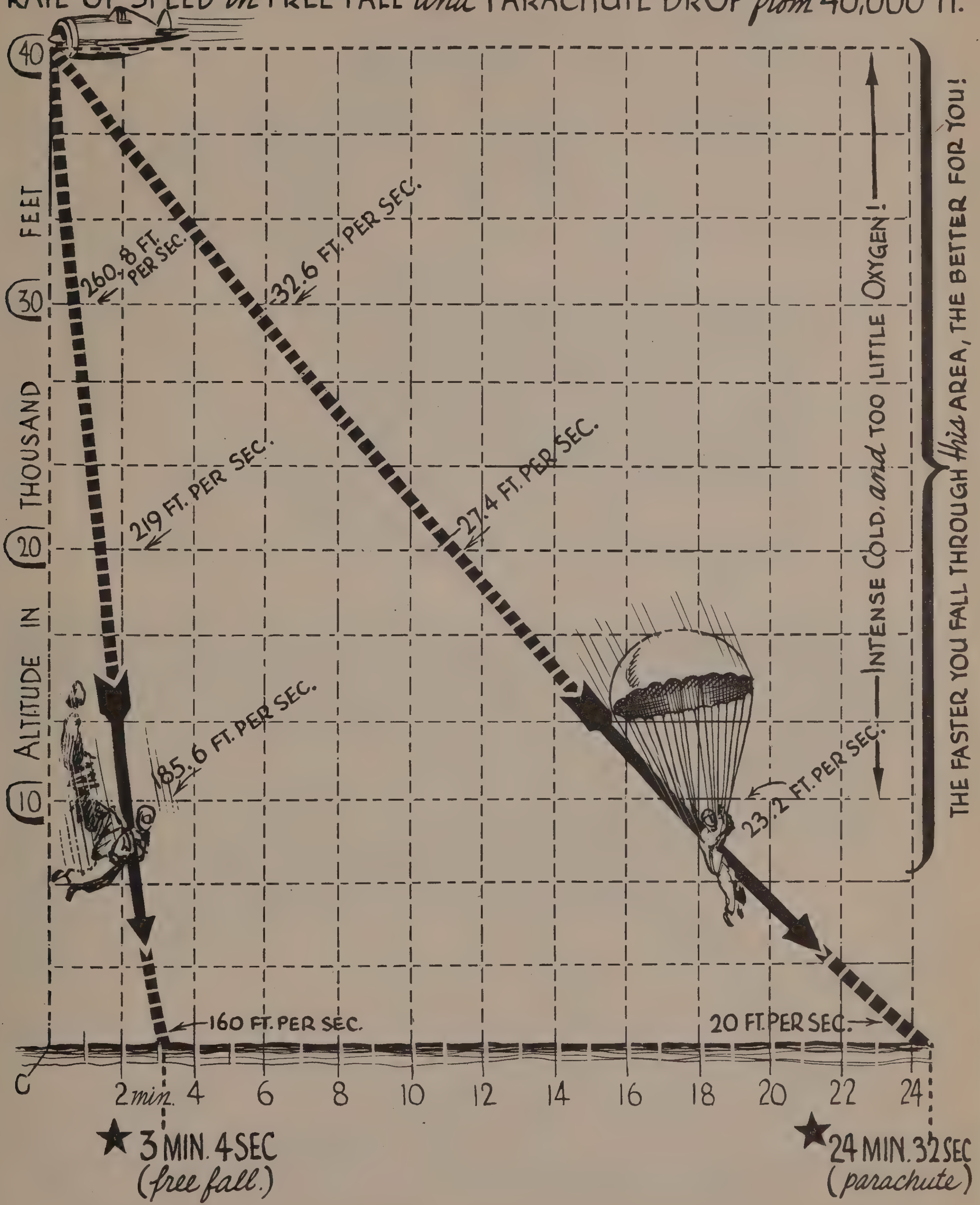
It is at least theoretically possible to hold your breath that long. Whether it can be done when <u>you</u> "hit the silk" depends on whether you breathe oxygen up to the point of jumping and on how much exertion is required to get out of the ship. In any event, you should delay removing your oxygen mask as long as possible and then take three or four deep breaths of pure oxygen. Hold this oxygen in your lungs as long as you can and then breathe as little as possible until you are well under 30,000 feet. Low-pressure chamber tests have indicated that if you lose consciousness from oxygen want, your fall into denser air will revive you in time to pull the rip cord.

To eliminate any risk, and to furnish you with an oxygen supply if you open your parachute too soon, a bail-out bottle is provided. This is a small oxygen cylinder designed to fit in the pocket of your flying-suit. You suck oxygen from it through a pipestem. The supply will last about 10 minutes if you are careful not to take in any outside air through your mouth or nose.

The walk-around bottle carried in bombers (see page 42) also can be used in a parachute jump if there is time to connect it to your oxygen mask. It will probably be jerked off, however, when you open your chute.

To avoid possible rupture of an eardrum during a free fall, you must constantly clear your ears as described on page 60. The danger is greater below 15,000 feet than above, because of the greater atmospheric pressure.

RATE OF SPEED *in* FREE FALL *and* PARACHUTE DROP *from* 40,000 FT.



NIGHT VISION

Everybody knows that one can't see as well at night as in the daytime, but not many know what can be done to improve night vision. This knowledge is important to the flyer because of the number of military operations which must be carried out in darkness.

In the first place, you have a blind spot in your eye when looking directly at objects at night. This spot covers an area of 5 to 10 degrees in our vision, and it originates from a small area in the center of the retina or "photo-film" portion at the back of the eyeball. It is 1,000 times less sensitive in dim light than the remainder of the retina, which is about 40 degrees in width and gives you night vision.

When you look directly at an object at night you are not using your eyes to the best advantage. You are trying to see through your blind spot. If, on the other hand, you look to one side of the object, you will be able to make it out much better.

That's the thing to remember at night: TO SEE THE TARGET MOST CLEARLY, DON'T LOOK DIRECTLY AT IT.

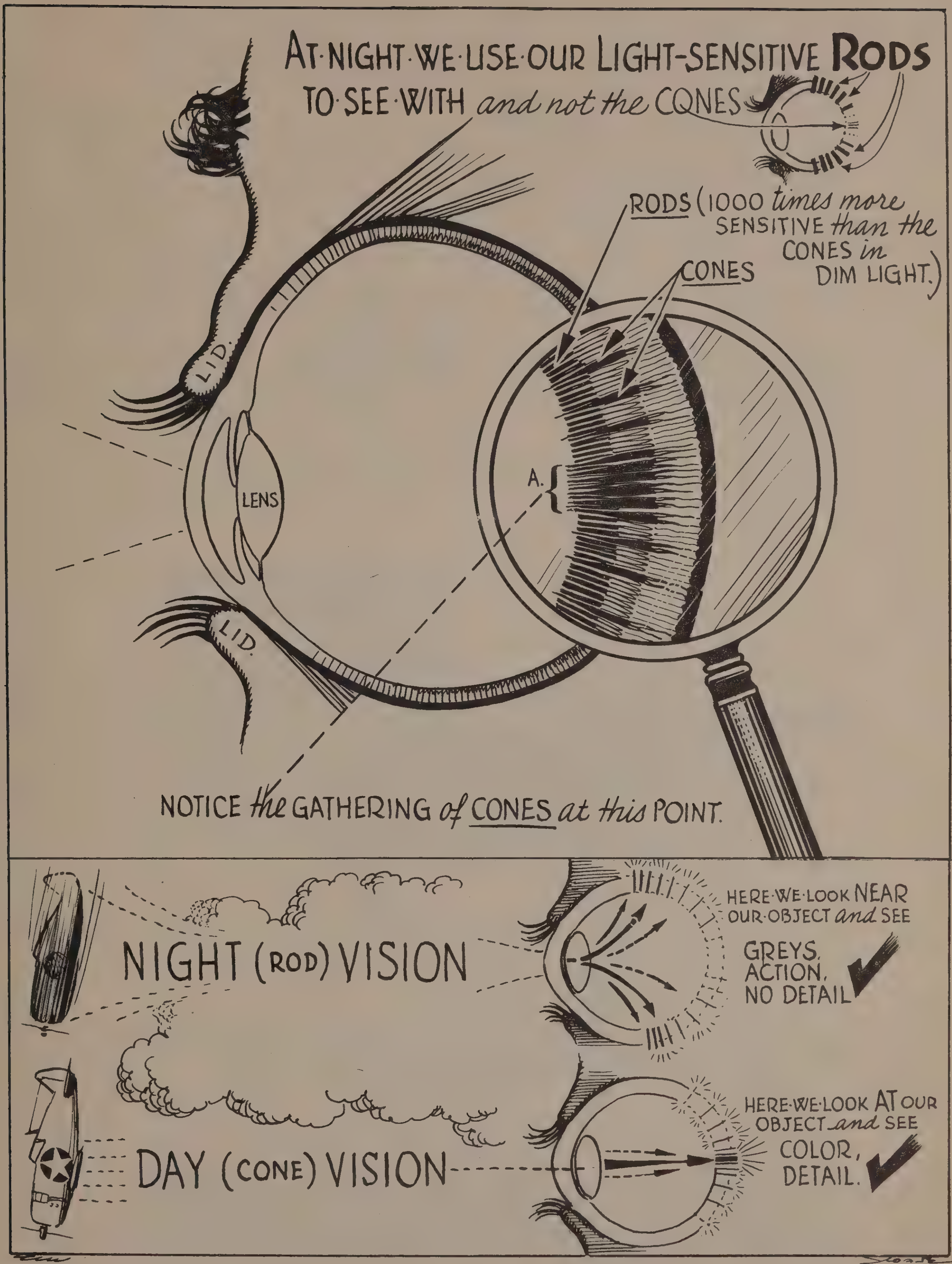

AT·NIGHT·WE·HAVE a BLIND SPOT
IN THIS LIGHT I LOOK SLIGHTLY AWAY to FIND my TARGET.
(THIS IS WHY)
"NIGHT BLIND SPOT"—ABOUT 5 to 10° MOSTLY CONE VISION
SENSITIVITY here FAIRLY CONSTANT to about a 40° ARC
MOSTLY ROD VISION IN THIS AREA

CONES, RODS, AND GOOD ADVICE

The reason you have a night blind spot is that this bull's eye area at the back of the eye is devoted to seeing in daylight. The area is filled with tiny organs called cones. The cones enable you to make out color and fine detail by looking directly at an object in bright light.

The outer area of the retina, in contract, contains very few cones but many rods. These are the organs which give you vision at night. They will not register color or detail but do detect movement of an object and picture it in different shades of gray.

Possession of good day vision does not mean necessarily that you can see well at night. There is great variation in the ability of individuals in this respect. The best can see with only one-tenth of the light needed by those with the poorest night vision. For this reason a selection of men with the best night vision is recommended for night flying. You can, however, improve upon inferior night sight by practicing off-center glances at objects in dim light. This can be done out-of-doors at night. With practice, some men have doubled the power of their night vision.


AT·NIGHT·WE·USE·OUR LIGHT-SENSITIVE RODS
TO·SEE·WITH and not the CONES
RODS (1000 times more SENSITIVE than the CONES in DIM LIGHT.)
CONES
LID.
LENS
A.
LID.
NOTICE the GATHERING of CONES at this POINT.
NIGHT (ROD) VISION
HERE·WE·LOOK NEAR OUR·OBJECT and SEE
GREYS. ACTION. NO DETAIL
DAY (CONE) VISION
HERE·WE·LOOK AT OUR OBJECT and SEE
COLOR, DETAIL.

EYE ADAPTATION TO DARKNESS

When you take in a matinee, the quick change from bright daylight to comparative darkness leaves you almost blind. But gradually your eyes adapt themselves and in 10 or 15 minutes you can look around you and identify your friends, if any.

It takes your "owl" eyes around 30 minutes to reach their full sensitivity. This change is great. At the end of 30 minutes, you can see a light 10,000 times dimmer than any you can see when you first step into the dark from a brightly lighted room.

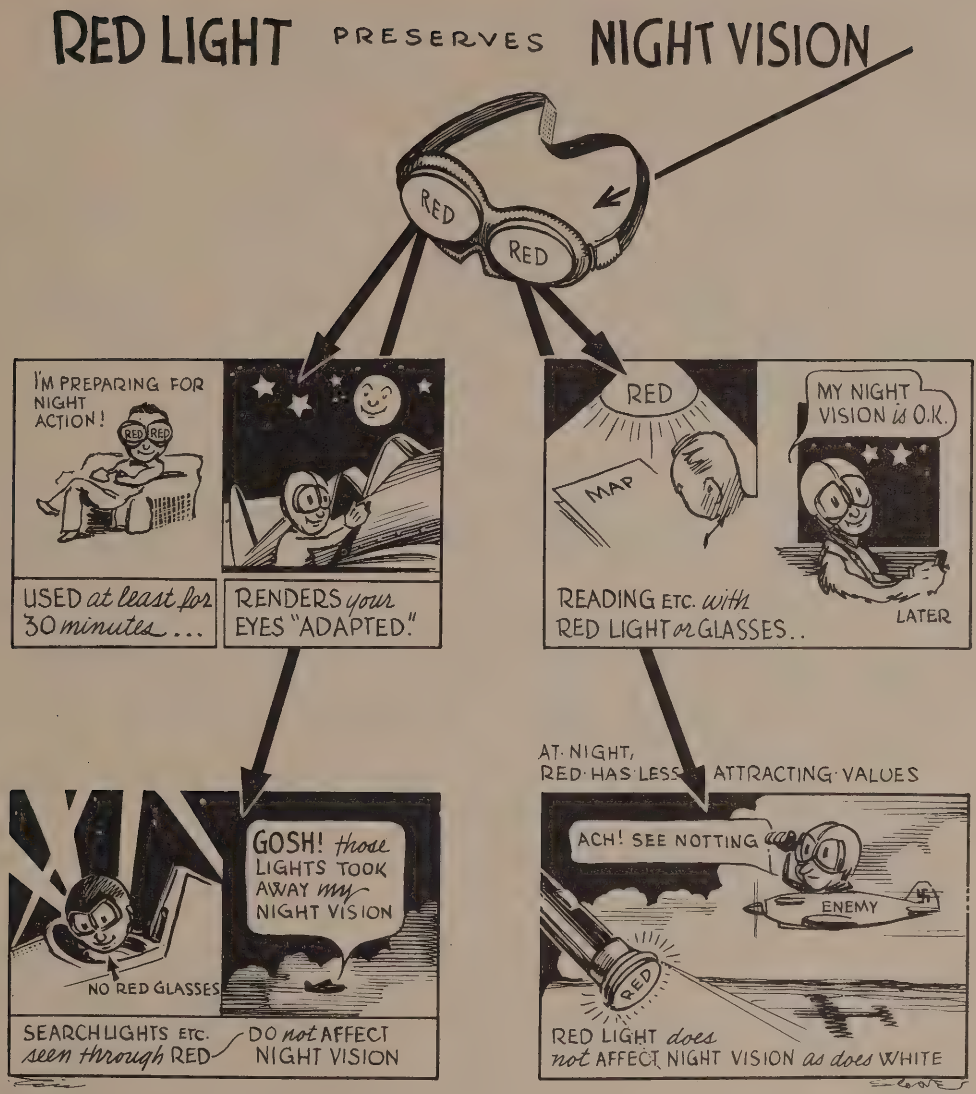
It follows, naturally, that a flyer preparing for a night flight should spend 30 minutes or as much time as possible in a dark or dimly lighted room before taking off. There is a simpler alternative, which is described in next paragraph.

The worst thing about working your eyes up to maximum night vision is that you can lose it all in a very short exposure to light, such as would happen if you turned on the plane's cabin lights or if you looked too long at a brightly lighted instrument board.

Because of this, all unnecessary lights should be kept off in your plane and all essential lights should be as dim as possible. Read the dials rapidly. Do not stare at the instrument panel.

AIDS TO NIGHT VISION

Sitting around in a dark room for a 1/2 hour is a rather boring way to prepare one's eyes for night flight. It is unnecessary if you have goggles with red lenses. These shut out all colors but red, which has the least effect on night vision. If red goggles are worn during the 30 minutes, you can go about your business in a lighted room. You can see well enough to read. You leave your red goggles on until you get into the dark, ready to take off.



Red light has other advantages. It can be used in planes to provide more light than would be tolerable for maximum night vision with any other color. Also, a flyer can slip his red goggles on when caught in a searchlight's beam and thus protect his night vision.

Windshields are bound to cut down a flyer's vision at night because they absorb and reflect light as it comes through and because they reflect any lights within the plane. To get maximum visibility at night, the windshield should be kept scrupulously clean and interior lights dimmed and shaded.

To have good night vision, you must get sufficient vitamin A. Fortunately, Army rations give you a plentiful supply of this vitamin. Foods rich in "A" include eggs, butter, cheese, liver, apricots, peaches, carrots, squash, peas, spinach, all types of greens, and cod-liver oil. When conditions make it impossible to get enough vitamin A in your rations, your diet may be supplemented with vitamin doses provided by the quartermaster through the direction of the flight surgeon. An excess supply of vitamin A, however, will not improve your night vision. Nor will it do any harm.

OXYGEN WANT AT NIGHT

As pointed out on page 22 vision is the first thing affected by insufficient oxygen in your blood. This is due to the marked sensitivity of the retina to lack of oxygen.

Night flying greatly magnifies the problem. At 12,000 feet your night vision is only half as good as at ground level, unless you are using your oxygen mask. This means that your ability to see will be markedly reduced even at 6,000 or 7,000 feet. The remedy is to wear your oxygen mask from the ground up at night. After you are in the air, it may be too late.

You may have noticed the reaction at night if you have waited until you reached 7,000 feet to turn on your oxygen. Your whole field of vision becomes red for a few moments as the hungry blood vessels of your eyes begin to get their full oxygen ration.

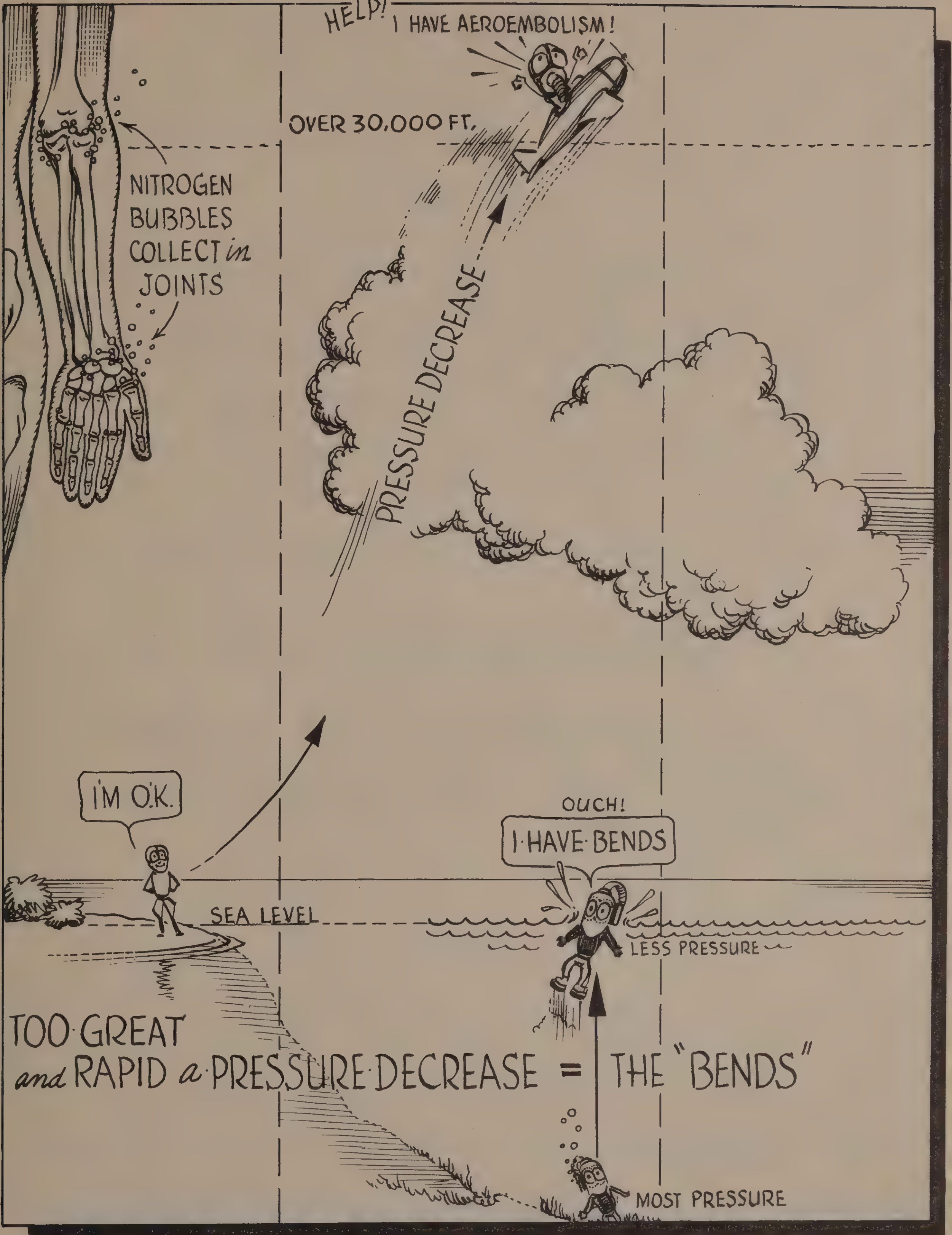

NOW *with* YOUR OXYGEN I LOOK CLEARER, EH?
SURE! THAT'S *why* WE USE IT ON **ALL** NIGHT FLIGHTS
WITH OXYGEN
WITHOUT OXYGEN
12,000 FT. ALT.
NIGHT VISION HERE *is* ONLY **HALF** *as* GOOD *as* ON EARTH.
DID YOU KNOW THAT LACK OF OXYGEN AFFECTS NIGHT VISION?
IN NIGHT VISION I SEE *different* SHADES *of* GRAY.

GETTING THE BENDS

When you pull the cap off a bottle of pop, bubbles rush to the top. Much the same thing can happen to you if the atmospheric pressure on your body is greatly reduced. In the pop, the bubbles are carbon dioxide forced into the fluid by pressure when the bottle is capped. They remain hidden in solution as long as the pressure is on. In the body the gas is nitrogen plus small quantities of oxygen, carbon dioxide, and water vapor, all of which have been absorbed by the flesh and blood and are held there by outside pressure.

When your plane climbs to a high altitude, the pressure of nitrogen in the body becomes greater than that of atmospheric nitrogen. Circulation of the blood tends to remove the excess of body nitrogen, but the process is slow and if you are flying at an altitude of 30,000 feet or more a condition known as bends is likely to result. Other names for it are aeroembolism and decompression sickness. It is believed that bubbles of gas seeking an exit appear in the joints and fat tissues as is the case in the bends suffered by deep-sea divers and caisson workers (sandhogs). The bubbles may appear in the blood and the muscles as well. In any event, the result is pain.

In a few instances the pain may occur under 30,000 feet but it is usually mild and passes away. Above that height, it can become so severe that an arm or leg is paralyzed. Occasionally a burning sensation in the lung called the chokes will appear. It may be followed by stabbing pains and a desire to cough, but this gives no relief. Severe cases experience a feeling of suffocation and a bluish discoloration of the nails and lips. Unconsciousness may follow.


HELP! I HAVE AEROEMBOLISM!
OVER 30,000 FT.
NITROGEN BUBBLES COLLECT in JOINTS
PRESSURE DECREASE
I'M O.K.
OUCH!
I·HAVE·BENDS
SEA LEVEL
LESS PRESSURE
MOST PRESSURE
TOO·GREAT and RAPID a·PRESSURE·DECREASE = THE "BENDS"

PREVENTION OF BENDS

Unless you are going above 30,000 feet for an extended flight, there is no need to worry about the bends. If you are, however, the best way to prevent trouble is to breathe pure oxygen for 45 minutes before taking off and then to continue inhaling 100 percent oxygen from the ground up. This method reduces the pressure of nitrogen in the lungs to zero and permits a large part of the gas in the flesh and blood to move out. It is called denitrogenation.

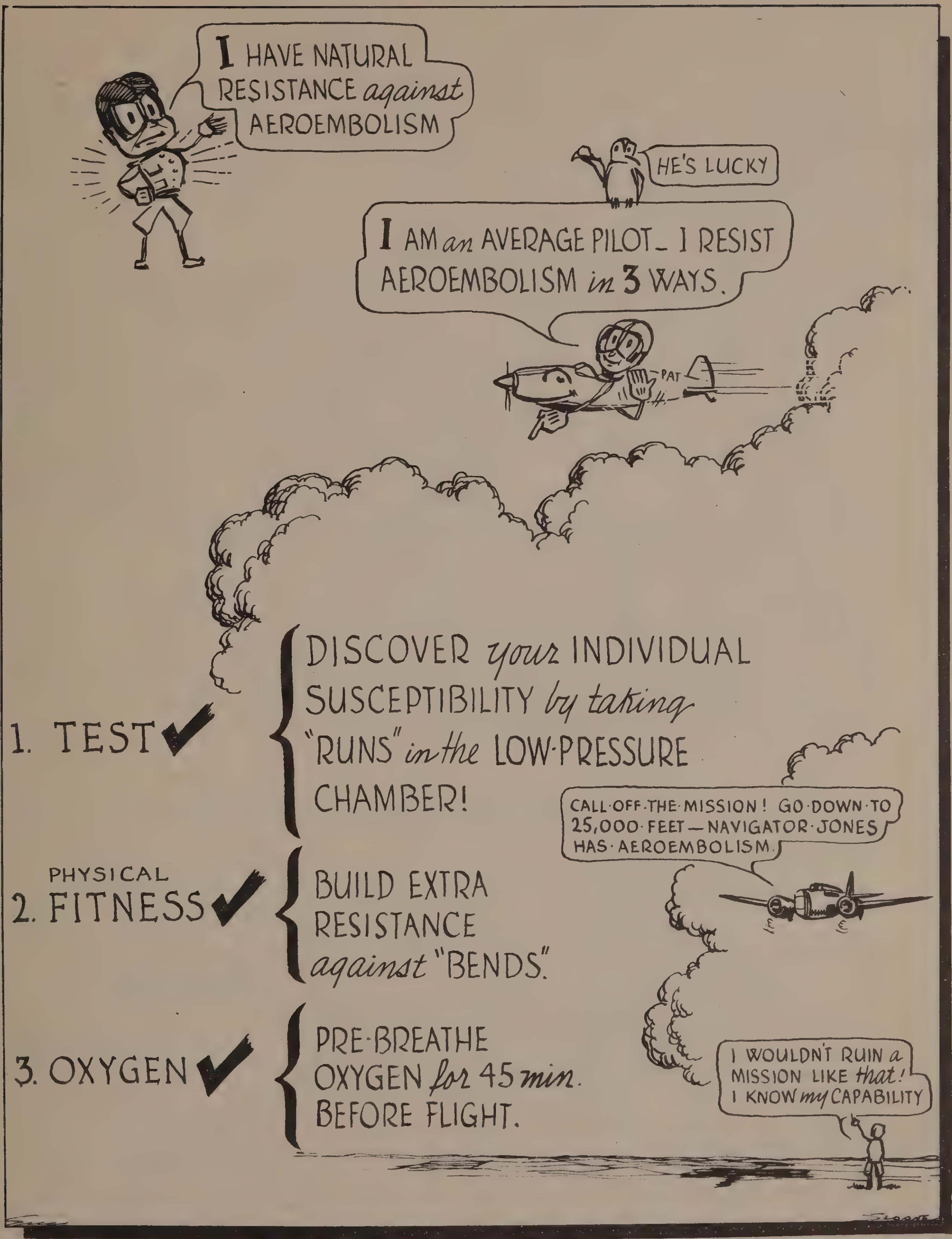
Long periods of flying at over 30,000 feet or an unusual amount of physical work above this altitude increase your chance of getting the bends.

Individual susceptibility to bends varies considerably. This can be determined to some extent by test "flights" in low-pressure chambers. The individual's susceptibility may vary, however, from day to day.

To assure himself of maximum resistance, the flyer should get plenty of exercise on the ground and keep himself in good physical condition. Overweight makes men more susceptible because of the tendency of the bubbles to collect in fat.

Once the bends occur, descent to 25,000 feet will usually cause the pain to disappear, although any lung trouble (chokes) may continue longer. Fatigue may be a complaint for several hours afterwards.

Where the flyer is near collapse or unconscious, descent is imperative if he is to be saved. Meanwhile he should be placed in a horizontal position with legs elevated if possible. He should receive 100 percent oxygen and, if breathing has ceased, artificial respiration. "Recompression" through an increase of barometric pressure (descent to lower altitude) will save the flyer in all cases if done in time. No permanent injury is known to have resulted.


I HAVE NATURAL RESISTANCE against AEROEMBOLISM
HE'S LUCKY
I AM an AVERAGE PILOT_ I RESIST AEROEMBOLISM in 3 WAYS.
PAT
1. TEST
DISCOVER your INDIVIDUAL SUSCEPTIBILITY by taking "RUNS" in the LOW-PRESSURE CHAMBER!
CALL·OFF·THE·MISSION! GO·DOWN·TO 25,000·FEET—NAVIGATOR·JONES HAS·AEROEMBOLISM.
PHYSICAL
2. FITNESS
BUILD EXTRA RESISTANCE against "BENDS."
3. OXYGEN
PRE-BREATHE OXYGEN for 45 min. BEFORE FLIGHT.
I WOULDN'T RUIN a MISSION LIKE that! I KNOW my CAPABILITY

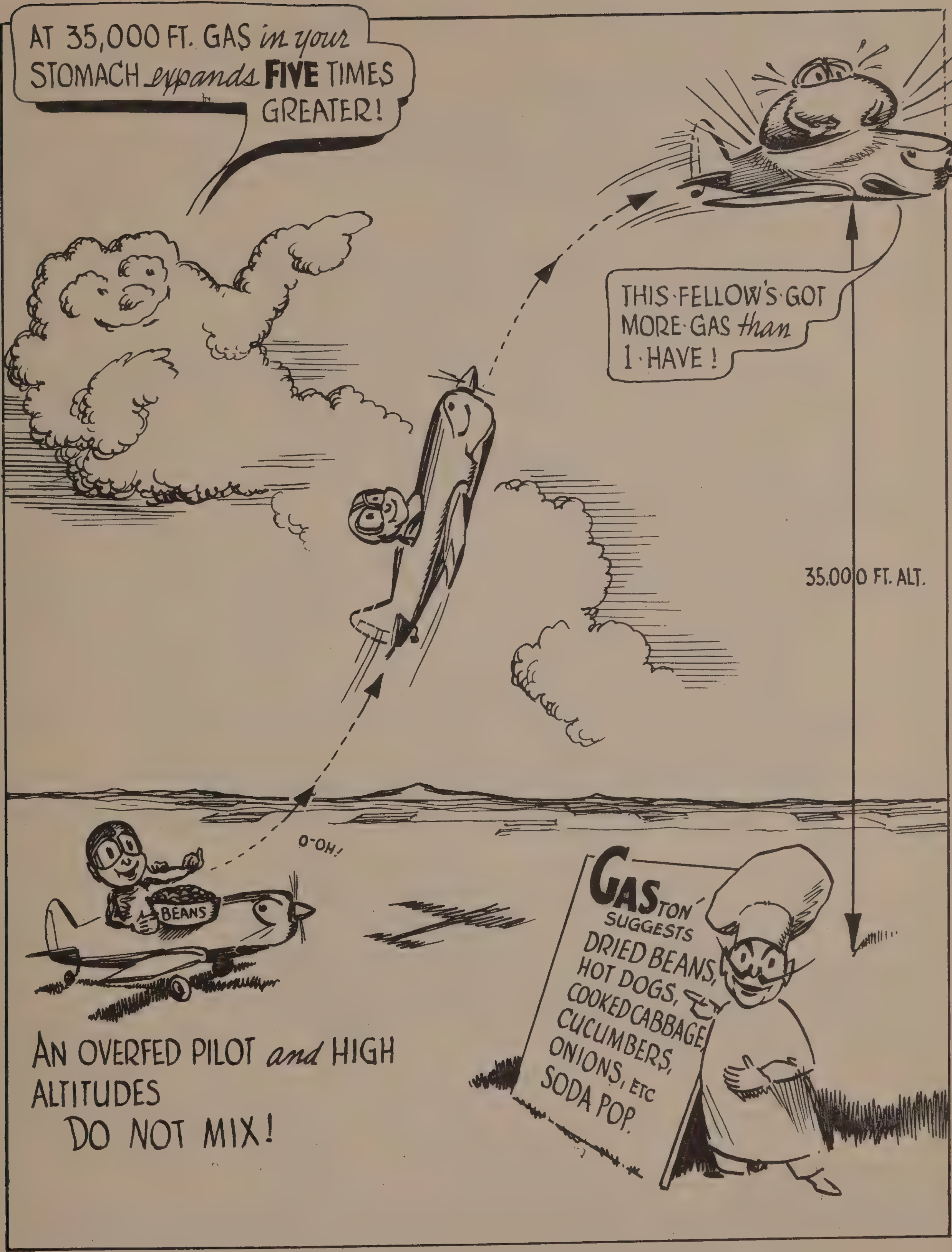
PRESSURE IN THE BELLY

Your stomach and bowels are not immune to the effects of changes in atmospheric pressure. When you ascend, the gas in your intestinal tract expands. At 18,000 feet it is double the volume at sea level; at 27,000, triple; at 35,000 feet, five times as great; at 40,000 feet the same amount of gas occupies 7.6 times as much space as at zero altitude.

This may give you visions of your middle swelling like a balloon as you go "upstairs." It can do that, but ordinarily relief comes through belching and the passing of gas, usually when you reach 20,000 or 25,000 feet. At about 30,000 feet you may get abdominal cramps because of pockets of gas in the intestinal loops.

The balloon effect has its comic aspects, but it is not funny to have a pain in your belly while you are trying to out-maneuver a Jap Zero, shoot a machine gun, or set a bomb sight.

There is always some gas in your stomach and colon, chiefly swallowed air, which you won't be able to do much about. But it is the excess which causes the most trouble. It may be avoided by proper diet, daily exercise, regular bowel movements, regular eating habits, and by not over-eating. The wisest thing you can do is to stay clear of the notorious gas-forming foods such as onions, cooked cabbage, raw apples, radishes, dried beans, cucumbers, fat or rich foods, melons, cauliflower, and the like.


AT 35,000 FT. GAS in your STOMACH expands FIVE TIMES GREATER!
THIS·FELLOW'S·GOT MORE·GAS than I·HAVE!
35,000 FT. ALT.
O-OH!
BEANS
GASTON SUGGESTS DRIED BEANS, HOT DOGS, COOKED CABBAGE, CUCUMBERS, ONIONS, ETC SODA POP.
AN OVERFED PILOT and HIGH ALTITUDES DO NOT MIX!

PRESSURE IN THE EAR

To be a good flyer, you've got to keep your ears open, not only to hear radio, intercommunication, and motor sounds, but also to keep from being grounded with ear trouble.

The trouble arises in the middle ear, an air-filled "box" behind the eardrum. The middle ear connects with the inner ear, which contains your sense organs of hearing and of balance, and with the eustachian tube. This is a slit, normally closed, running into the throat.

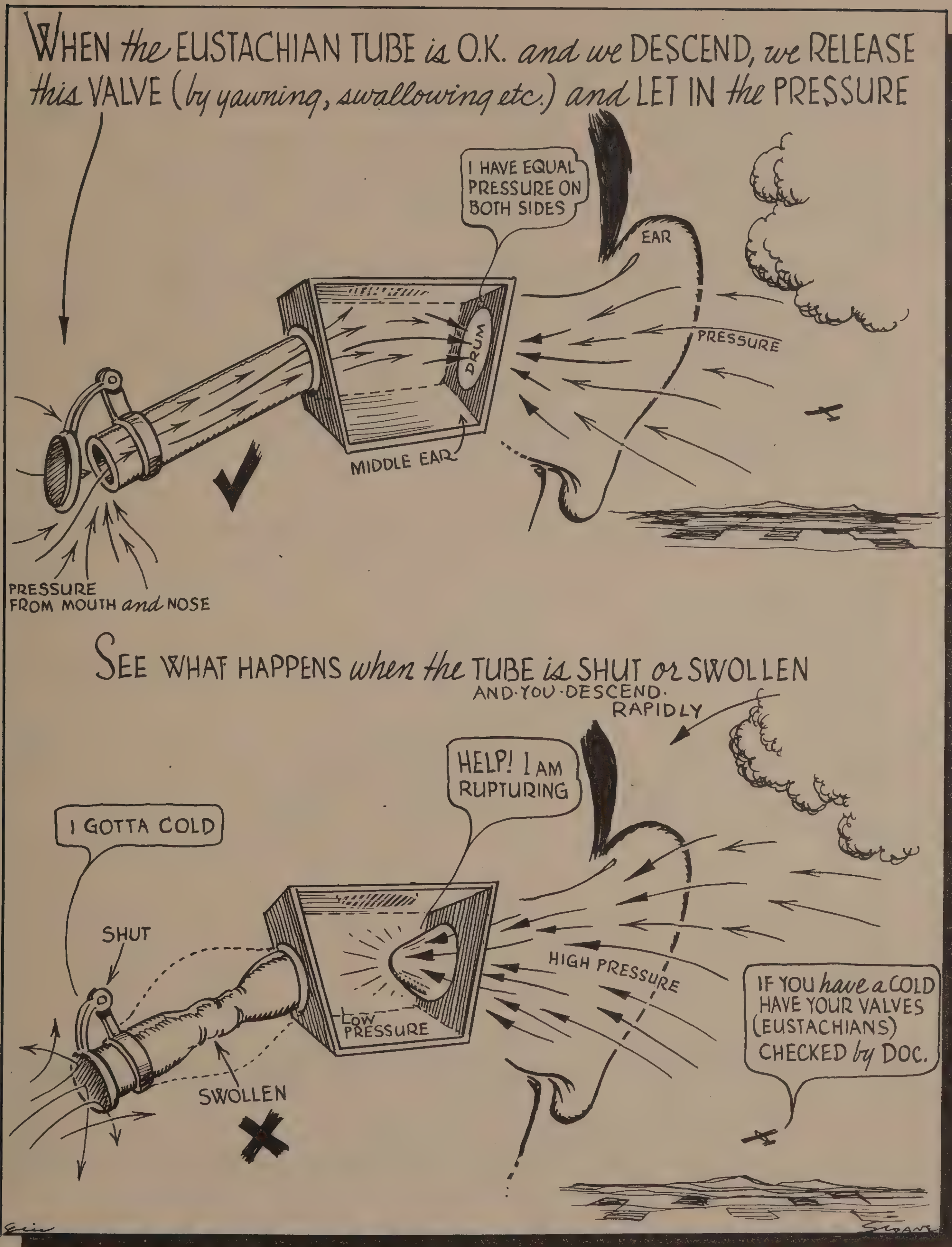
When you gain altitude, the outside pressure drops and the air remaining in the middle ear expands. At first this causes the eardrum to bulge a little, but then the surplus air slips through the eustachian tube to the throat. When this happens there is a click in the ear.

Ascents present no problem, but during a descent this automatic balancing of outside and inside pressure may not take place because the eustachian tube resembles a flutter valve, working in one direction.

Considerable pain and even rupture of the eardrum may befall you if the tube doesn't permit some high-pressure air to pass into the low-pressure area behind the drum. This usually can be accomplished by swallowing or yawning, which stretches the eustachian tube open. If that doesn't happen, air can be forced into the middle ear by closing the mouth, pinching the nose, and blowing gently. If only one ear is involved, hold the other closed while you blow.

The most important fact to remember is to clear your ears when the slightest amount of pressure appears. If you allow the difference between the inside and the outside pressure to become too great, the precautions above are not likely to help. If you are unable to clear your ears and the pressure becomes painful, you should return, if you can, to an altitude at least several hundred feet higher than that at which you first experienced trouble. From there you should descend slowly while constantly attempting to clear your ears. If this fails, you should go to the Flight Surgeon as soon as you land.

Unfortunately, a cold may cause inflammation and swelling in the eustachian tube, completely blocking off the passage of air. Descent under such a circumstance is likely to produce pain, deafness, and a ruptured ear. While the ear will heal and your hearing probably will return to normal, such a misfortune will ground you for many days and sometimes weeks. DON'T FLY WITH A COLD UNLESS IT IS ABSOLUTELY NECESSARY. IF IT IS, SEE YOUR FLIGHT SURGEON FIRST. See following drawing No. 42 for pressures at low altitudes which give greatest effects upon descent.

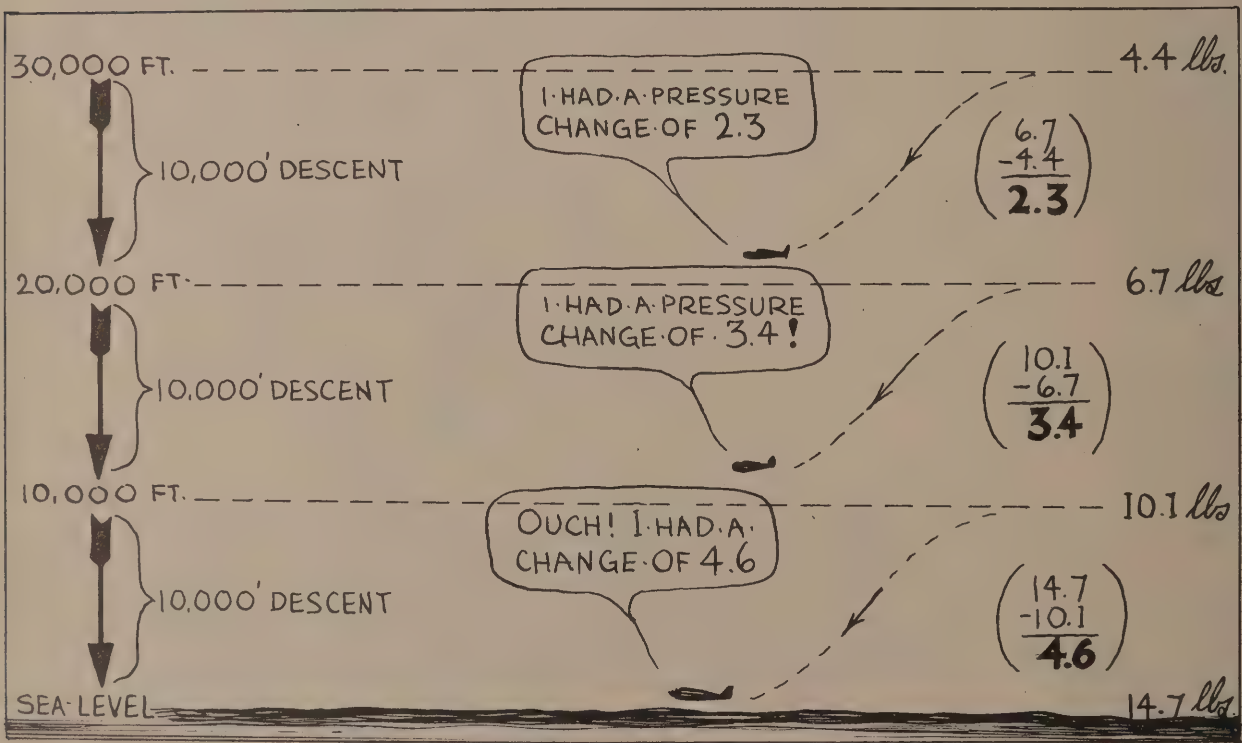

WHEN the EUSTACHIAN TUBE is O.K. and we DESCEND, we RELEASE this VALVE (by yawning, swallowing etc.) and LET IN the PRESSURE
I HAVE EQUAL PRESSURE ON BOTH SIDES
EAR
DRUM
PRESSURE
MIDDLE EAR
PRESSURE FROM MOUTH and NOSE
SEE WHAT HAPPENS when the TUBE is SHUT or SWOLLEN AND YOU DESCEND RAPIDLY
HELP! I AM RUPTURING
I GOTTA COLD
SHUT
HIGH PRESSURE
LOW PRESSURE
SWOLLEN
IF YOU have a COLD HAVE YOUR VALVES (EUSTACHIANS) CHECKED by DOC.

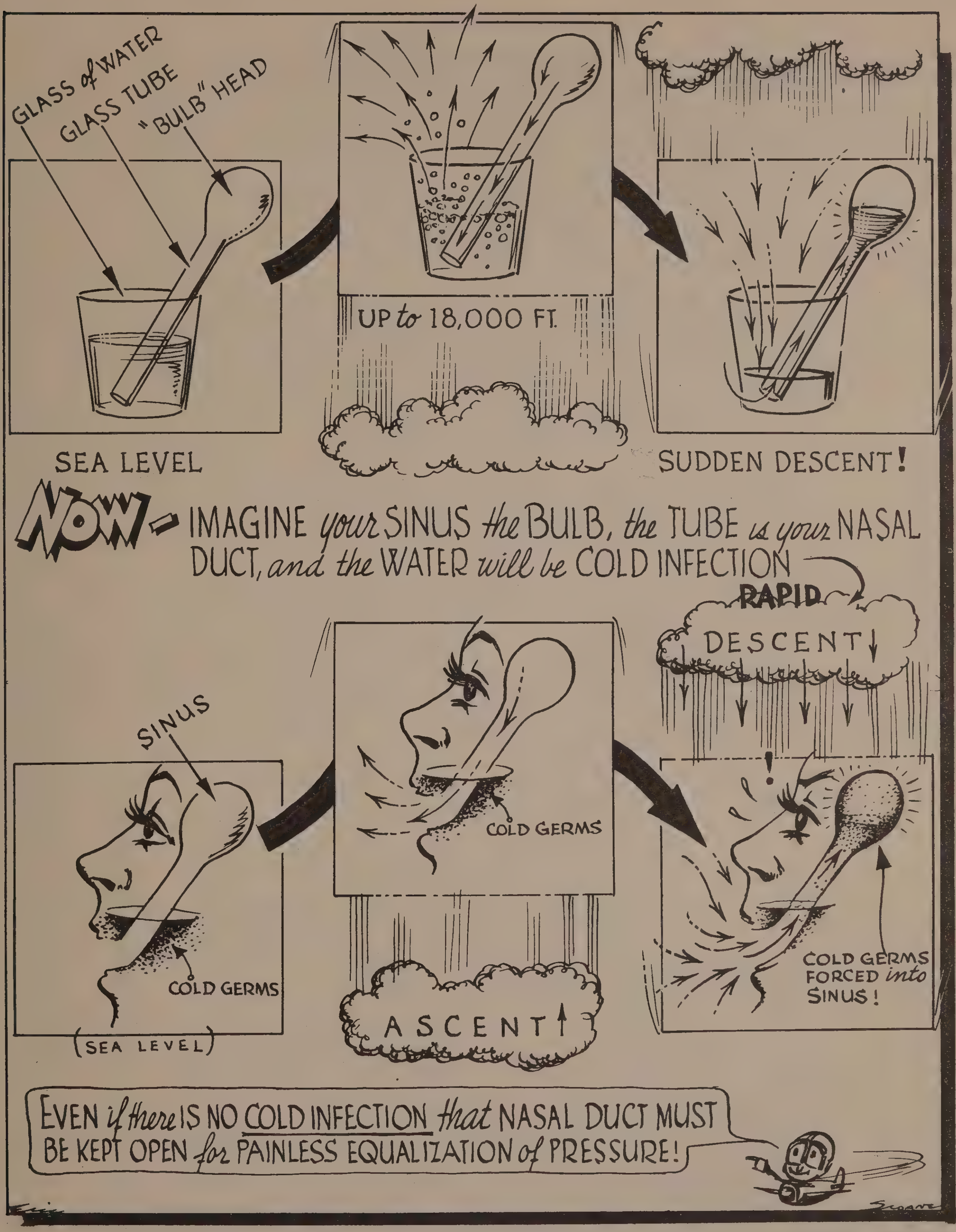
PRESSURE IN THE SINUSES

The sinuses present pretty much the same problem as the middle ear. They are air-filled, membrane-lined cavities in the skull. The sinuses open into the nose from the cheeks, forehead, and bone between the eyes. Normally, air passes into the sinuses readily in either direction, so that neither ascents or descents should cause you any trouble.

An acute cold or a chronic infection, however, can block off these passages, and cause trouble. If you've ever had a sinus headache, you know it is pretty fierce. Too much pressure of the air that can't get out when you go up, or of the air trying to get in when you go down, will produce the same kind of pain.

To yawn, swallow, or blow out with the nose and mouth closed may help to equalize pressure in the sinuses, just as it does in the ears. Again, it is wisest not to fly when you have a cold. Continued trouble with changing pressure in the sinuses demands the attention of a Flight Surgeon. Also, he can see whether there is any scar tissue or growths blocking the sinus openings into the nose. The next page demonstrates air pressure and its effect upon the sinuses.




GLASS of WATER
GLASS TUBE
"BULB" HEAD
UP to 18,000 FT.
SEA LEVEL
SUDDEN DESCENT!
NOW - IMAGINE your SINUS the BULB, the TUBE is your NASAL DUCT, and the WATER will be COLD INFECTION
RAPID DESCENT
SINUS
COLD GERMS
(SEA LEVEL)
COLD GERMS
ASCENT
COLD GERMS FORCED into SINUS!
EVEN if there IS NO COLD INFECTION that NASAL DUCT MUST BE KEPT OPEN for PAINLESS EQUALIZATION of PRESSURE!

THE JOB OF KEEPING WARM

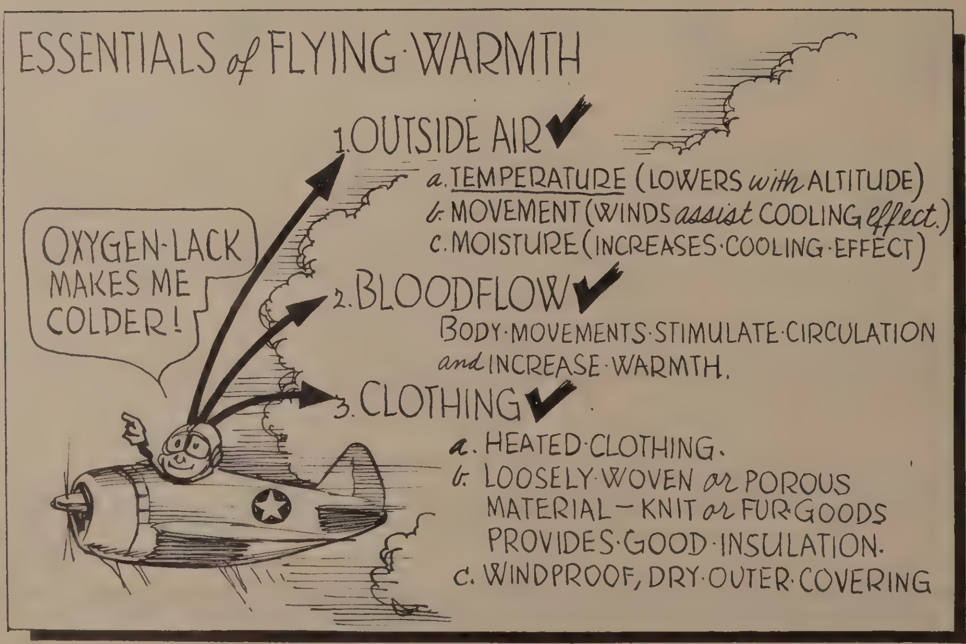
The flyer may be exposed to temperatures ranging from 160°F above zero (88°C) when grounded in the desert to 67°F below zero (-55°C) when flying at an altitude of 35,000 feet. This is a range, of course, far beyond what the body's heating and cooling system can accommodate, even when supported by the usual "put on, take off, and go without" technique of changing clothing to fit the weather.

The temperature range of body comfort is marked, thermostat-fashion, at the lower level by shivering (a form of exercise!) and at the upper level by sweating. The flyer's big problem is quick changes from the sweating to the shivering level.

One thing he should remember is that in facing cold at high altitudes sufficient oxygen is more important than red flannel underwear. The combustion rate depends on the oxygen supply, and this in turn requires good circulation of the blood. The first parts to get cold are the hands and feet, and flyers with poor circulation will suffer more quickly than those with good circulation. Tight-fitting gloves or shoes should be avoided. Silk gloves inside heavy mittens and winter flying boots over two or three pairs of wool socks and felt inner soles are probably most effective.

The winter flying suit will maintain the flyer's comfort indefinitely at 30°F (about -1°C), while summer flying clothes will feel all right for any period of time at 70°F (21°C). The period of comfort becomes less with any adverse change in temperature.

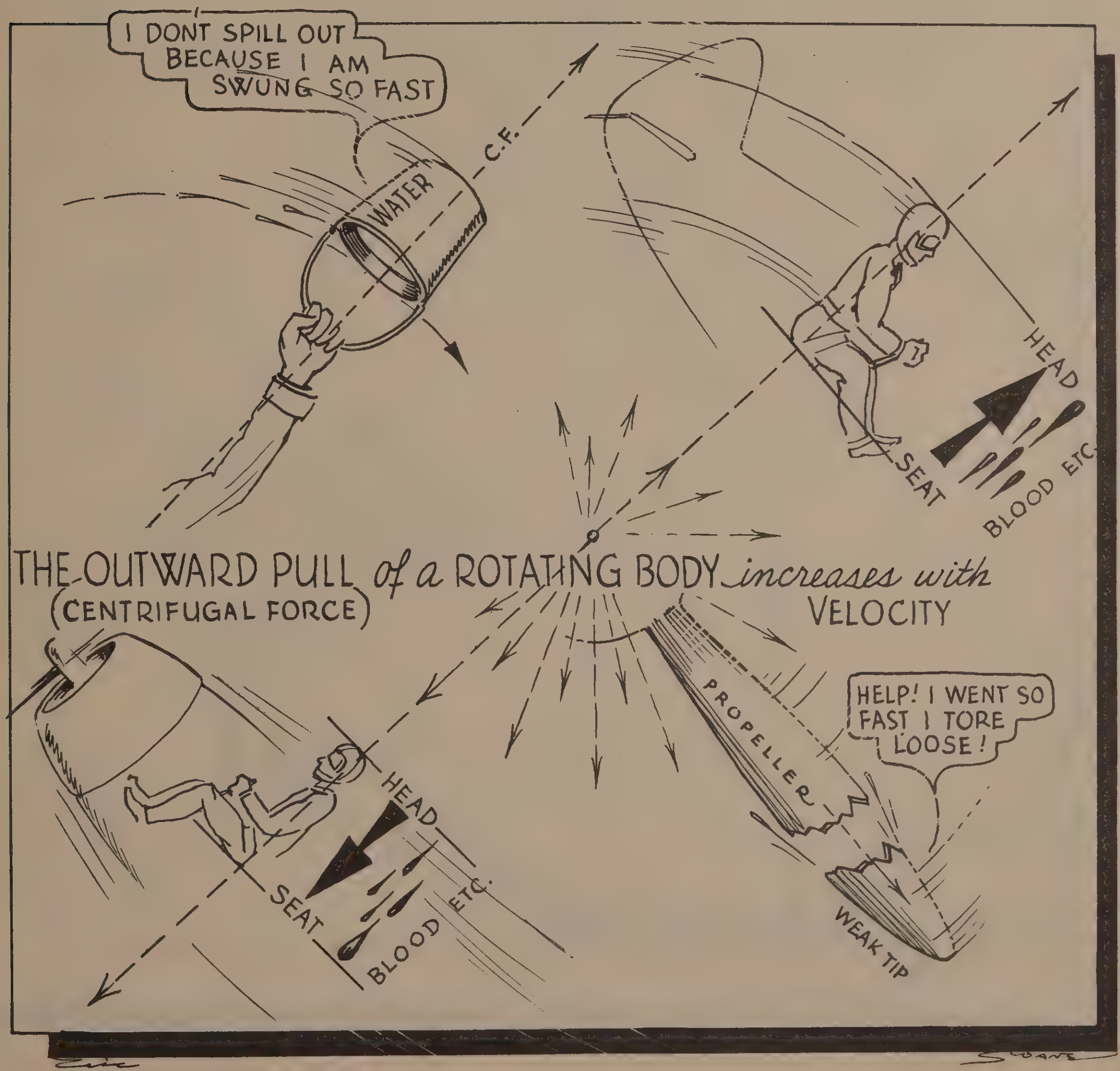
Cabin heating is the ideal solution for the flying warmth problem, and present systems in pursuit planes are fairly reliable up to 30,000 feet. Efficient heating in bombers is more difficult to achieve, especially for the protection of the gunners in the tail and waist of a bomber. Their best hope is the electrically heated suit, which is good for any sub-zero temperature likely to be encountered, but has the disadvantage of offering no lasting protection in event of power failure. The electrically heated suit is inadequate for protection should a forced landing occur in the Arctic. For this reason, it is best suited for use in flights over moderate or tropical zones.



BLACKING AND REDDING OUT

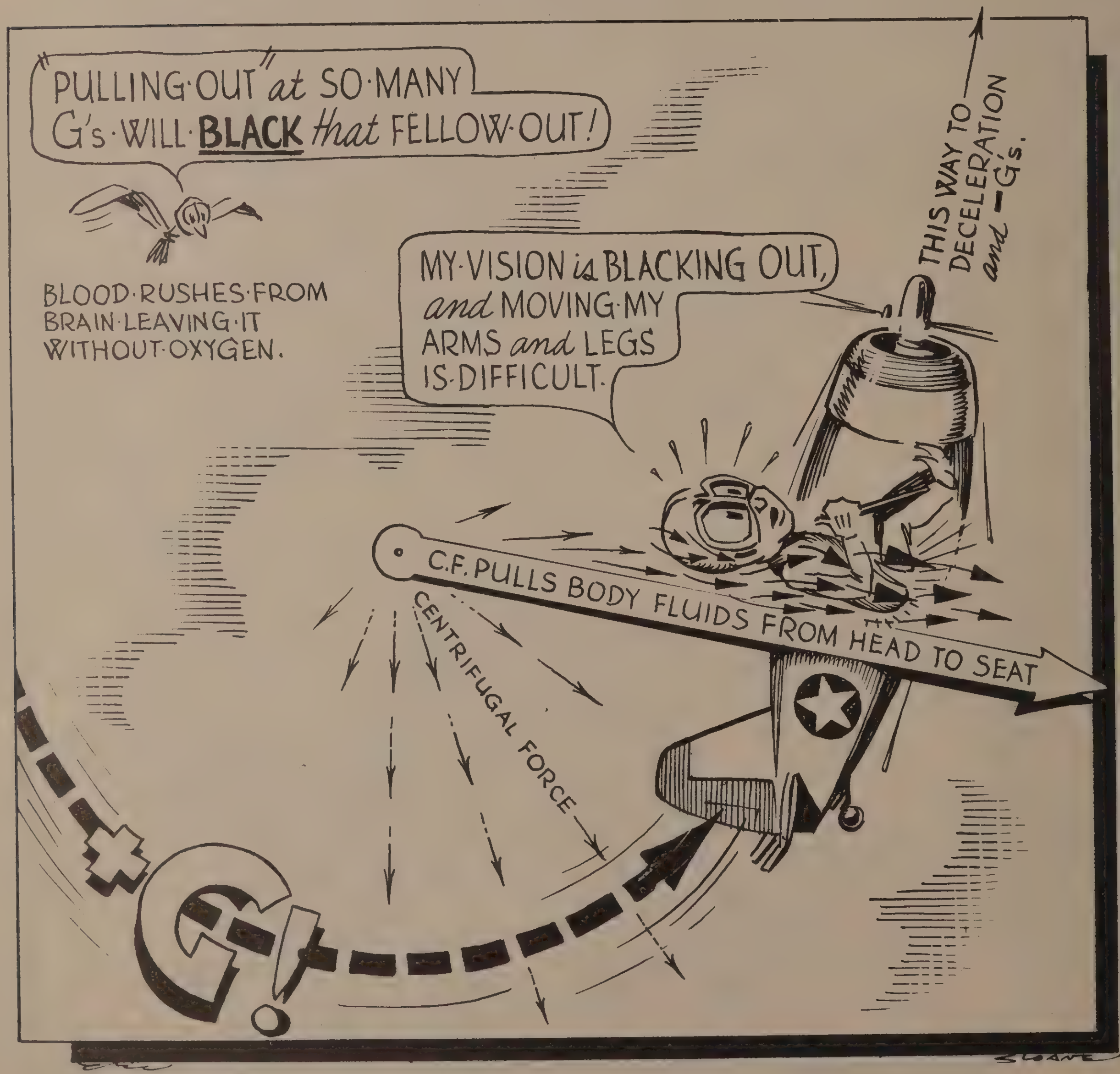
Your body in flight is subject not only to pressure effects due to changes in altitude but to changes in the force of gravity as well. Gravity, hereinafter known as "G," is always pulling you down. You defy it when you fly. The weight of your body at rest, or of any object, is equal to the force of gravity, and is called "1G." When a force several times that of gravity (2G, 4G, etc.) pulls at you, there may be serious trouble.

The extra force may come as a change in speed or as a change in direction. Changes of speed are of importance when you stop suddenly, as in a crash or a high-velocity parachute opening. Changes of direction occur when you move in a turn, loop, or dive. If you are standing in a bombardment aircraft, be careful not to fall on sudden turns as you may suffer a sprain or fracture. Changes of direction also present a more subtle physical problem. Centrifugal force throws your body at a tangent to the line it is compelled to travel. It is the old story of swinging a bucket of water overhead without spilling a drop.



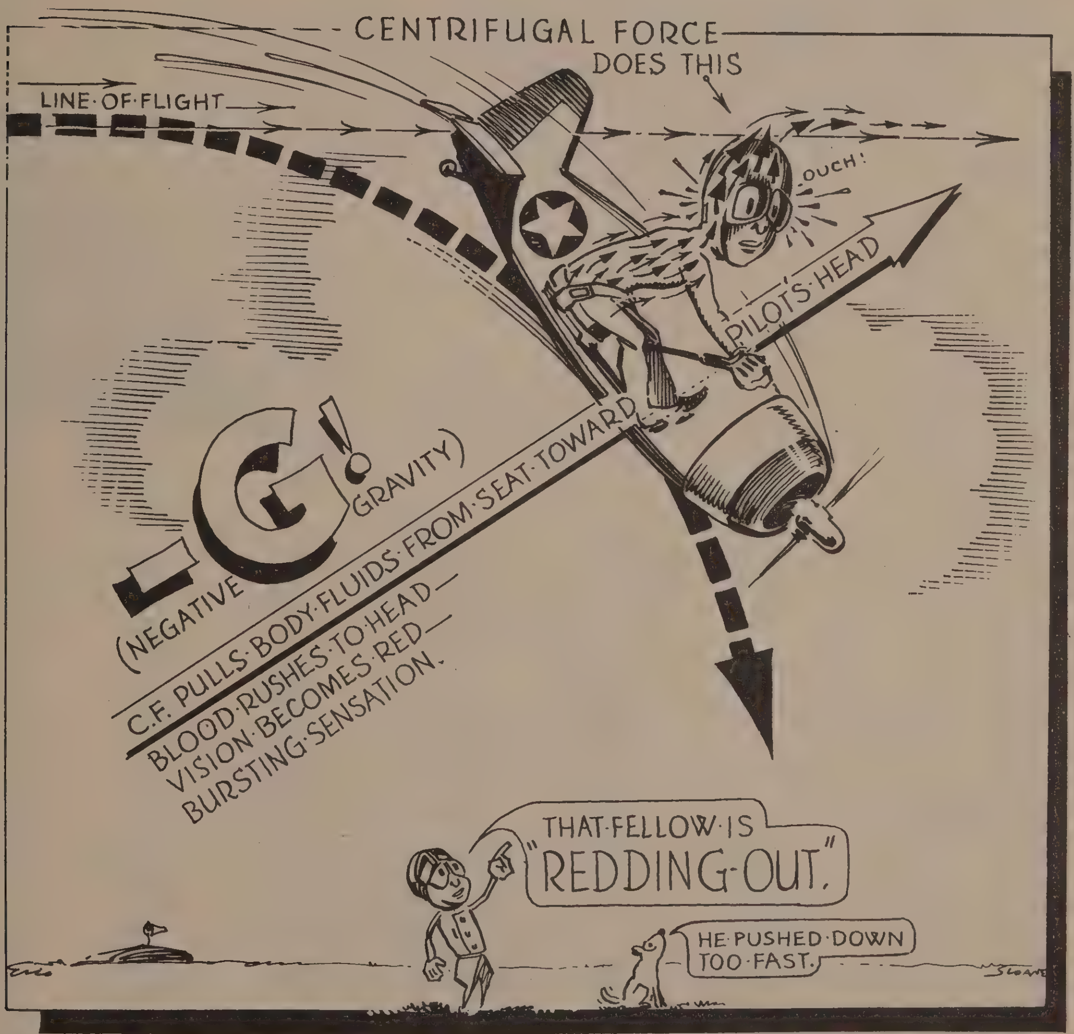
When you do an inside loop you give positive acceleration, or +G, to the gravity load of your body. The effect is to cause the blood in your body to move from head to seat. The draining of blood from your brain first causes your eyes to "see" gray. If the force is increased a little, everything goes black. This is the "blacking-out" which most commonly occurs in the pull-out from a power dive. You do not become unconscious when blacking out, although this may follow if the force continues.

In contrast, the effect is the opposite when you do an outside loop. You give negative acceleration, or -G, to the gravity load of your body. The centrifugal force now pulls the blood from seat to head. The blood pushes into your brain and causes your vision to go red. Your eyes bulge and your head throbs with pain. This is "redding out."



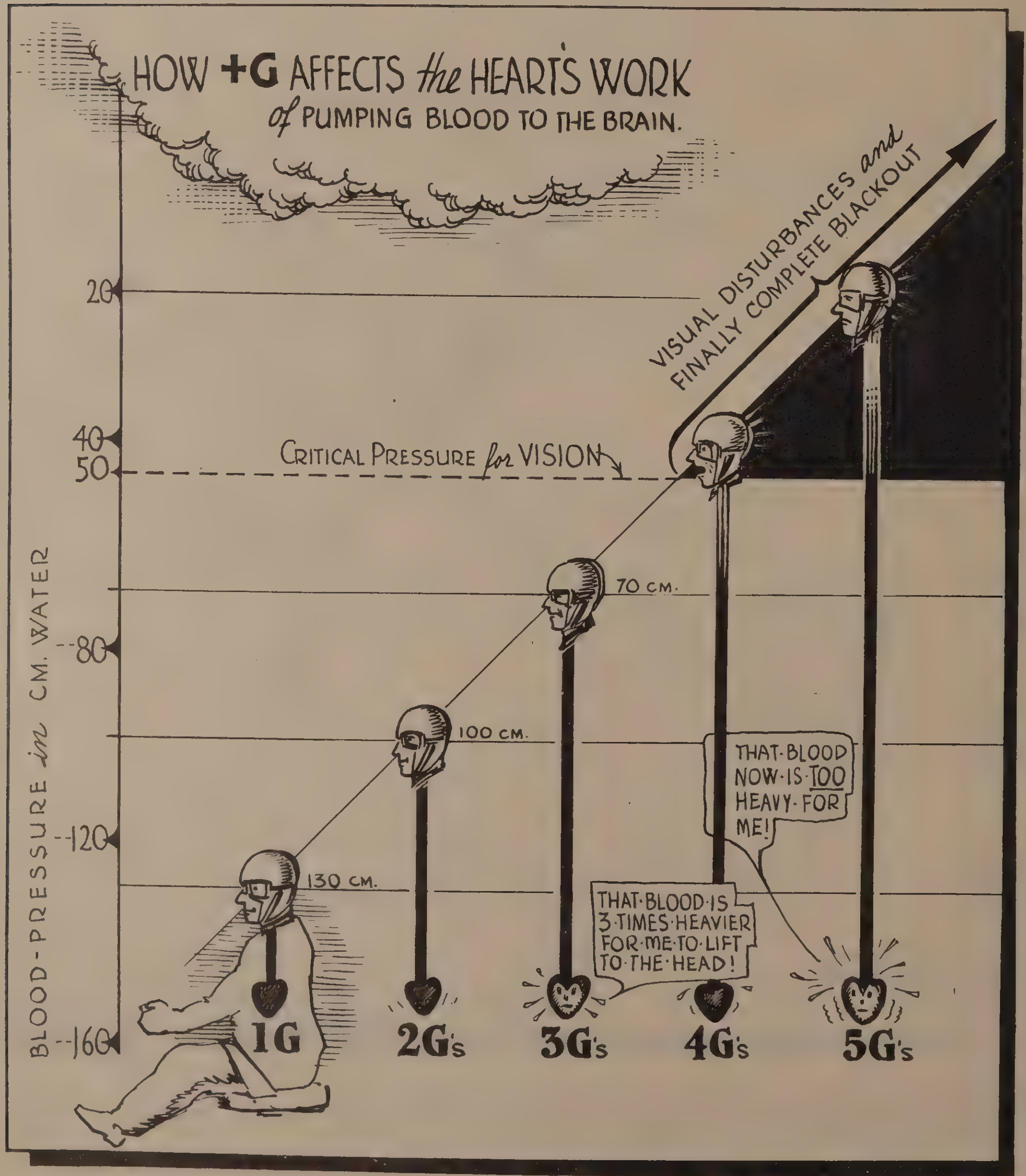
You can take more +G than -G. In the average flyer, blacking out will occur at +4 to +5G if continued from 3 to 5 seconds. More than that will cause unconsciousness, but when the force ceases, consciousness and sight are recovered in from 5 to 10 seconds. Your maximum tolerance for -G is about 3. If the force continues after you red out, serious damage may be done to your brain and eyes. After even less than -3G, you may need several minutes or hours to recover.

There is a column of blood approximately 12 inches high between your heart and brain. The harder +G swings your blood in the opposite direction, the more difficult it is for your heart to pump blood into your brain and keep you conscious. At +5G your heart must pump five times harder, which is the same as if the column of blood were 60 inches long. Meanwhile the blood pressure falls, due to a pooling of blood in the lower extremities--the volume in each leg may increase as much as a pint. A normal blood pressure of 130 at 1G may drop all the way to 20 under a centrifugal force of 5G.



The best way of saving yourself the disastrous consequences of too much G is to avoid maneuvers which produce excesses. If you are a pilot of a dive bomber or a pursuit plane, this is not always possible. There are some things you can do, however. You can stay out of outside loops, which are the most dangerous, you can "peel off" on a dive to get away from the greater strain of a "push-down," and you can seek to increase your natural muscular and nervous tension when you pull out of a dive or make a tight circle. Relaxation, the secret of athletic success and ordinarily a boon to good flying, is not recommended in this instance--it only permits the blood to drain more easily while centrifugal force grips you. Any stiffening of your abdominal and leg muscles will help prevent the flow from head to seat. A good way to create such tension is to "YELL LIKE HELL" as you enter a pull-out.

Anything which reduces physical fitness increases the danger of blacking or redding out. Fatigue, excessive smoking or drinking, loss of sleep, oxygen want, colds, or recent sickness all will lower your G resistance.




"G" STANDS·FOR·ONE·UNIT of GRAVITY·LOAD and the ACCELERATION·IT·EFFECTS.
I HAVE 1G ACTING UPON ME
I HAVE -1G SENSATION!
I·FEEL FUNNY!
"PUSH DOWN" -G (POSSIBLY -2G)
PUSH·DOWN
-G
FREE ACCELERATION +G, CLEAR BRAIN and VISION. POSSIBLY 350 MPH.
BLACKOUT OCCURS·HERE
CENTRIFUGAL·FORCE·PULLS ME·OUTWARD - I·AM·7 TIMES HEAVIER!
BEGINNING·OF·"PULL·OUT"
VISION DARKENS here
THE·PULL·OUT
+7G (POSSIBLY)
SLOANE

LIVING THE BALANCED LIFE

If the physiological complications of human flight have you standing on your head by now, the role played by your three senses of balance may interest you. These senses are always at work letting your brain know what position your body is taking, but they get their roughest workout when you can't get your feet on the ground.

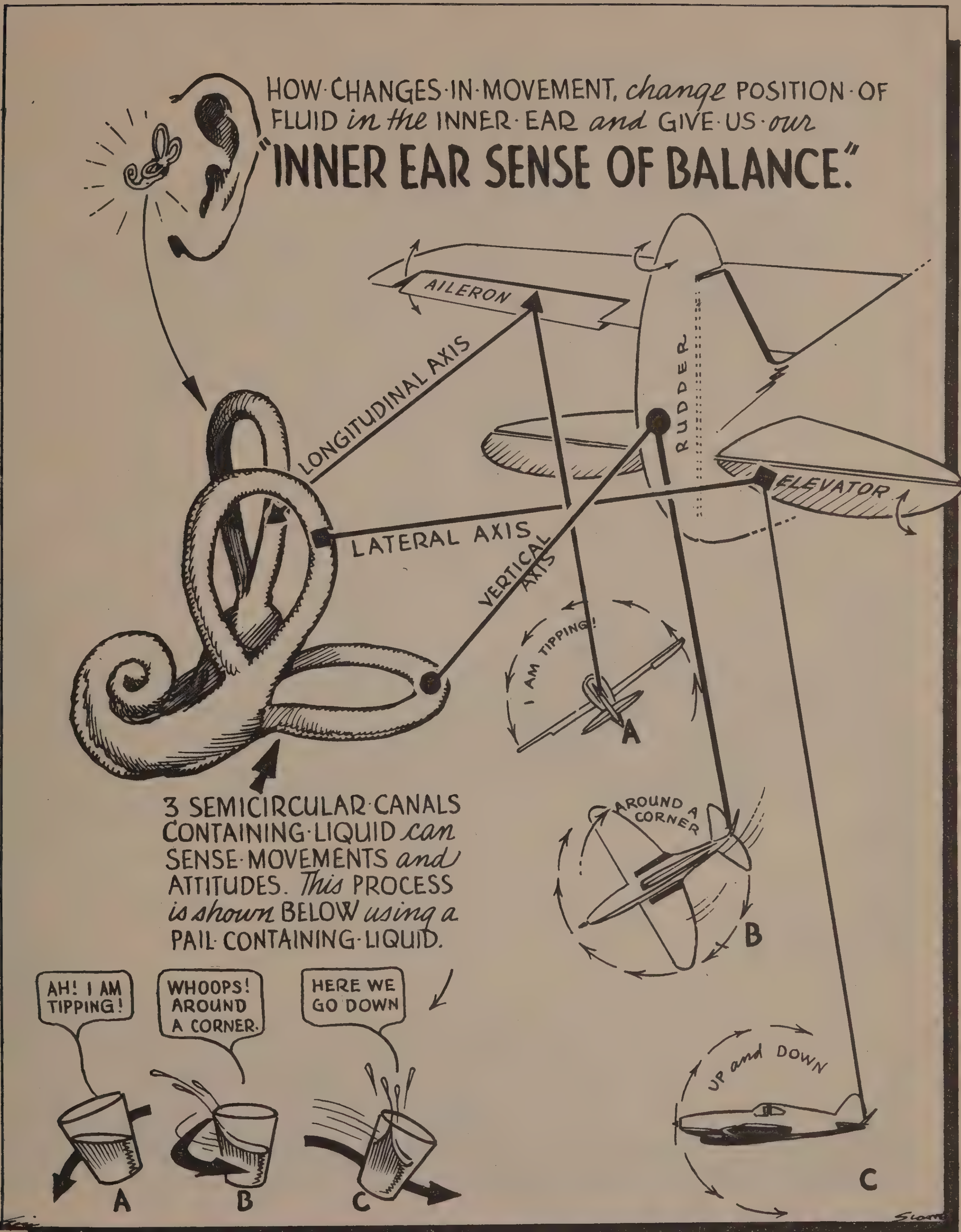
Your eyes are probably of first importance in maintaining balance and particularly in orienting you in relation to other objects, fixed or moving. When you are moving, you continue to see other objects as if you were standing still. That's the way it looks. If you whirl around and around, you get dizzy (out of balance) because you lose your visual reference point. Ballet dancers avoid this by jerking their heads around rapidly and fixing their eyes on the same object at each turn.

A second factor in determining position is the labyrinth of semicircular canals in the inner ear. Any movement of your head causes the fluid in these closed canals to push in the opposite direction, vibrating tiny hairs lining their walls. This sends a signal to the brain. Taken alone, the signal will trick you, however, if you rotate too swiftly in one direction and then slow down, stop, or reverse your movement. You continue to feel as if you are going in the original direction. Your eyes, of course, will tell you differently if you have them open. If you don't, you'll land on your ear.

You also have muscle sense, arising from changes in pressure and tension on the flesh, joints, skin and internal organs. Responding to gravity, the sense of touch, and air pressure, your body feels what position it is in. When you are in motion, however, muscle sense records all movements as if they were made in a straight line, up or down. Again, it is the eyes which tell you most reliably of circular movements. Like the labyrinth, the muscle sense is important in flying. It enables you to "fly by the seat of your pants."

You have heard of airsickness. Like seasickness, it makes you sick to your stomach and is caused by disturbance of your sense of balance. The disturbance arises chiefly from conflict in the brain between sensations as recorded by the labyrinth, the eyes, and the muscles. Fear, odors, cold, noise, and vibration contribute.

Medical remedies for airsickness thus far have been of little use. Preventive measures include oxygen, warm and comfortable clothing, cushions to absorb vibration, cotton ear plugs to reduce noise, avoidance of greasy foods and large amounts of beverages before flying, keeping the eyes on some point outside the plane when possible, ventilation to remove odors, and taking a position as near to the plane's center of gravity as possible.


HOW·CHANGES·IN·MOVEMENT, change POSITION·OF FLUID in the INNER·EAR and GIVE·US·our
"INNER EAR SENSE OF BALANCE."
AILERON
LONGITUDINAL AXIS
RUDDER
ELEVATOR
LATERAL AXIS
VERTICAL AXIS
I AM TIPPING!
A
AROUND A CORNER
B
UP and DOWN
C
3 SEMICIRCULAR·CANALS CONTAINING·LIQUID can SENSE·MOVEMENTS and ATTITUDES. This PROCESS is shown BELOW using a PAIL·CONTAINING·LIQUID.
AH! I AM TIPPING!
WHOOPS! AROUND A CORNER.
HERE WE GO DOWN
A
B
C

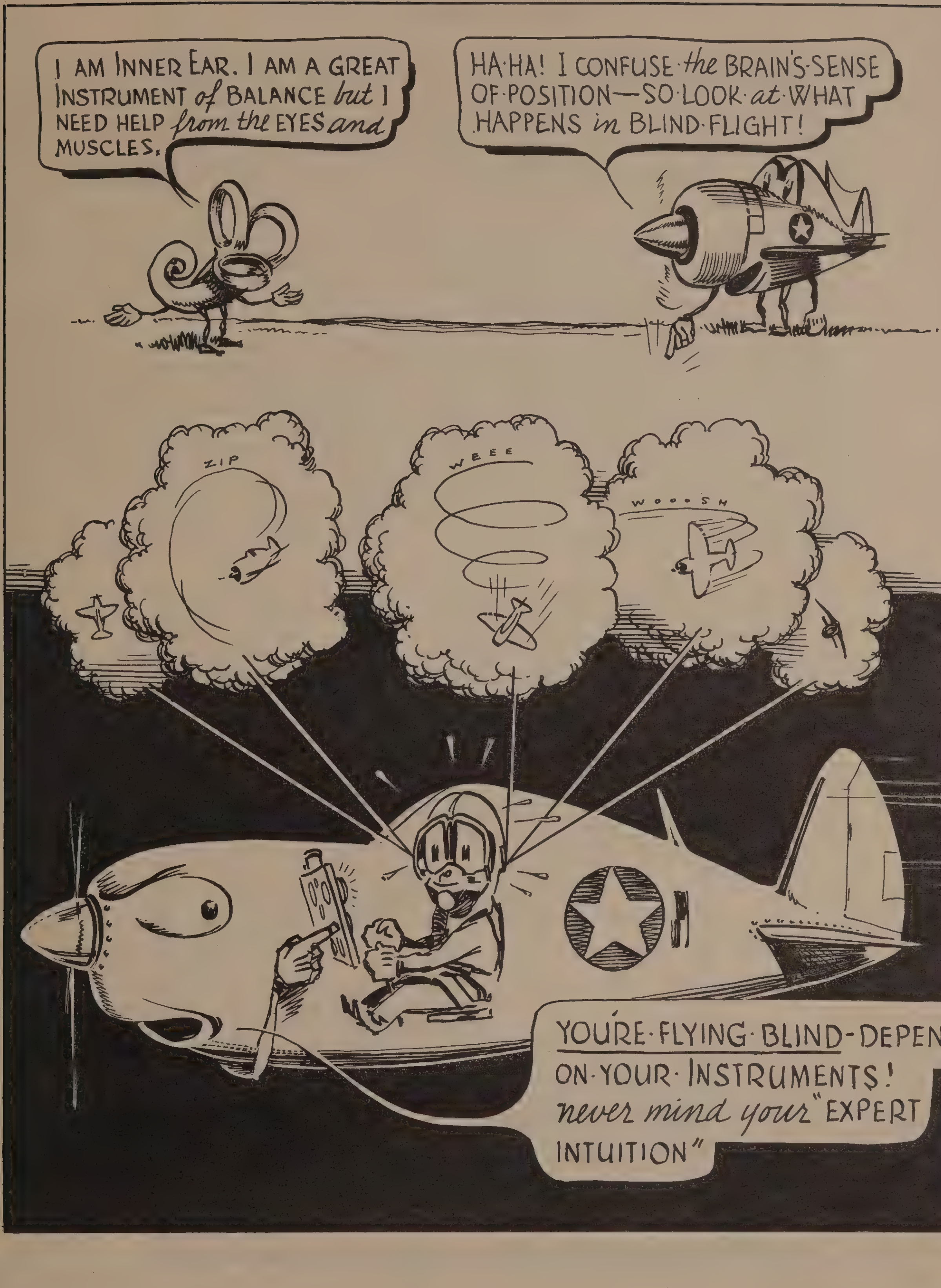
HOW NOT TO FLY BLIND

Homing pigeons cannot fly blind. When they are blindfolded and released from a plane, or run into a fog and can't see, they simply set their wings for a glide to the ground. If a homing pigeon, biologically adapted for orienting itself in aerial space, refuses to fly a course without visibility, then you, a flightless ground animal, can't expect to do it either, not by relying on your senses. A lot of men who thought they were smarter than a pigeon have died proving it.

The earth becomes a pretty remote place when you get high up in the air. As you go up it becomes more difficult to judge depth and orient yourself in space. Nevertheless, the flyer ordinarily depends on the earth as a reference point. When he can't see out because of clouds, fog, or darkness, he is severely handicapped in his sense of balance.

Tests on blindfolded men walking or driving a vehicle show that they invariably move in a circle which spirals inward until they are in a tight spin. Tests made on men flying blind in loops, tilts, and turns likewise have disclosed discrepancies in their sense of direction. Thus, if you bring your plane out of a spin you will have the sensation that you are still in it and will continue to turn in the opposite direction to compensate. A second spin may result, and the result of this sense failure is frequently fatal.

Fortunately, man has been smart enough to invent airplane instruments to make up for his deficiencies in balance when flying blind. These are primarily the air-speed, turn-and-bank, and vertical-speed indicators, the altimeter, and the magnetic compass. Auxiliary instruments giving a quick picture of position are the gyroscopic compass and the flight indicator (artificial horizon). The big difficulty is in persuading the beginner to believe these instruments instead of his deceptive labyrinth and muscle senses. To fly blind, and live, you must learn to disregard your own sensations.


I AM INNER EAR. I AM A GREAT INSTRUMENT of BALANCE but I NEED HELP from the EYES and MUSCLES.
HA·HA! I CONFUSE the BRAIN'S·SENSE OF·POSITION—SO·LOOK·at·WHAT HAPPENS in BLIND·FLIGHT!
ZIP
WEEE
WOOOSH
YOU'RE·FLYING·BLIND-DEPEND ON·YOUR·INSTRUMENTS! never mind your "EXPERT INTUITION"

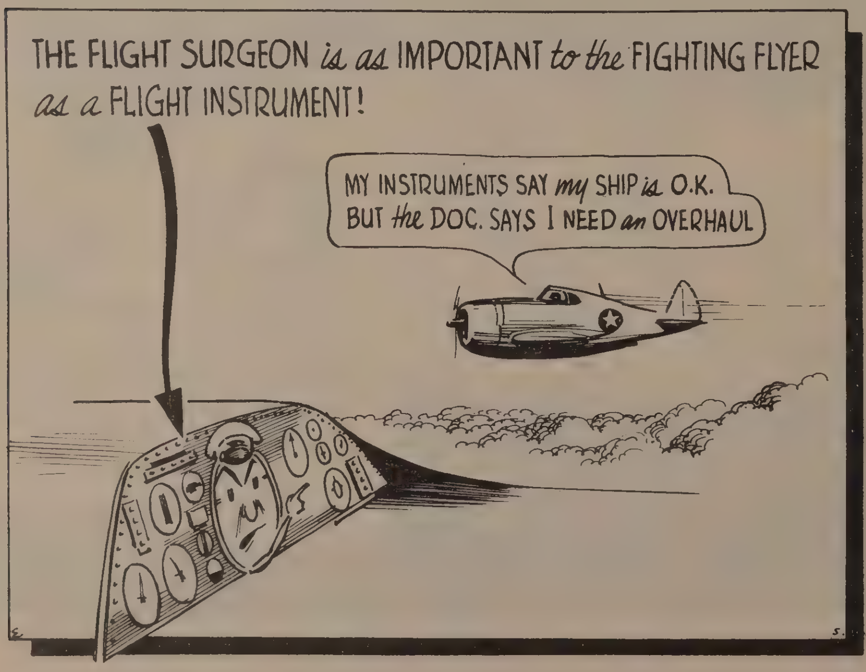
THE FLIGHT SURGEON

You have heard of esprit de corps. Even if you haven't, you are practicing it as a member of the Army Air Corps. This "spirit of the body" binds you to your fellow flyers and urges you to make any sacrifice to maintain their good will. It makes good fighters into a great fighting force. Unfortunately, the same spirit of self-sacrifice when carried to extremes can endanger the fighting efficiency of a group of flyers. What we mean is that when you try to keep going heroically after you are done out, you may fail at the expense of not only yourself, but your squadron and your country.

That is the job of the Flight Surgeon: to protect you and your group from yourself. He has the power to ground you when he thinks your sacrifice will endanger you or the group. Naturally, your first reaction will be one of resentment. No flyer wants to be left behind.

Yet when you go stale from flyer fatigue, and no one knows better than you when you reach this state, you should be left behind to fly another day. Staleness piles up from a multitude of minor strains on your nerves and muscles: the strain of monotony, of sitting in one position, of listening by the hour to the radio over the continuous hum of the engines, of ranging your eyes over the instrument panel, of watching for enemy planes in every cloud bank, of trying to remember everything you're supposed to do. Your judgment becomes erratic, your reactions are slow, you don't feel rested after sleep, your appetite is jaded, and you "wish to hell you could get away." But you won't report how you feel, and you may run yourself and your fellows into trouble.

Everything known about aviation medicine demands that you report how you feel to the Flight Surgeon. Guided by his instruments, his training in observation, and the comments of the C.O., he can quickly tell whether or not you should be grounded. REMEMBER! THE FLIGHT SURGEON IS WITH YOUR SQUADRON NOT TO GROUND ITS FLYERS BUT TO KEEP THEM IN THE AIR. He wants you fit to fly, and, whether or not you realize it, he's your friend.



DON'T DOCTOR YOURSELF

The Army Air Forces is making every effort to give you the best medical care in the world. In the face of this effort, you are pretty dumb if you think you can doctor yourself better than the Flight Surgeon can.

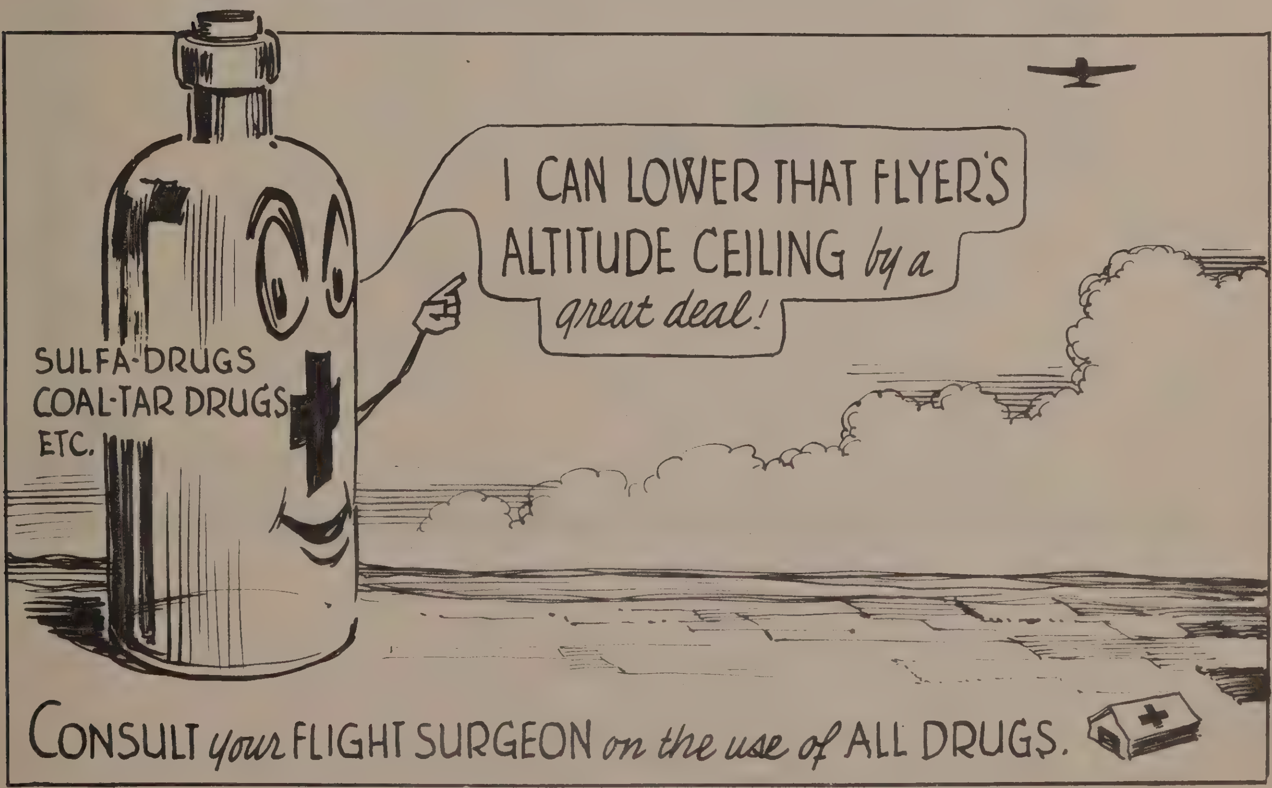
Self-medication is dangerous. Aspirin or any similar drug product containing acetanilide, phenacetin, or other coal-tar derivatives should be avoided except when prescribed by the flight surgeon. They produce oxygen want, as described on pages 22, 23.

This is especially true of the sulfa drugs, which include sulfanilamide, sulfathiazole, sulfapyridine, and sulfadiazine. They may not only reduce your blood's capacity to carry oxygen but may slow down your mental perceptions, cause nausea, and even make you "see things."

A lot has been said about flyers' use of pep-up drugs such as caffein and benzedrine. The idea is to sharpen one's wits, prevent sleepiness, and improve the way you feel. The Air Forces Medical Corps is looking for such a drug, but as yet hasn't found one that will accomplish these advantages without the greater disadvantages of being more or less poisonous, hard to take, habit-forming, and likely to leave you worse off after the effects have passed.

Don't fly with a cold before consulting your Flight Surgeon. He can judge better than you whether you should or should not do so, and, in any event, his advice and treatment may save you from unnecessary risks and loss of flying time.

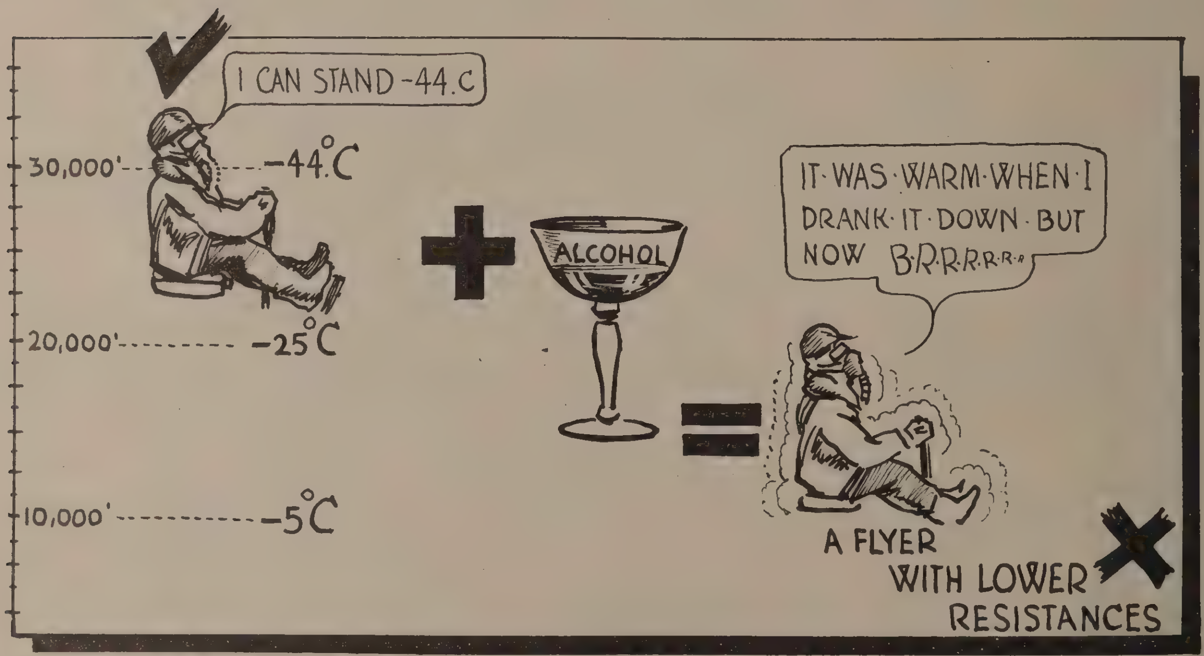
When you need medical attention, see your Flight Surgeon. He's your friend and your doctor.



EFFECTS OF ALCOHOL

In theaters of combat operations liquor is likely to be so hard to get that it will constitute no problem in flying.

There is no question that alcohol has harmful effects on men under the strains of flying. Far from being "the best little overcoat in the world," a couple of drinks actually lower your resistance to cold at high altitudes, thus counteracting the value of specially designed flying suits. This is the result of its interference with the body's absorption of oxygen from the blood (see page 16) and an increase in the pulse and breathing rates. Such a speed-up will raise your skin temperature and cause abnormal losses of heat. Alcohol, as you doubtless know, affects the vision, dulls the senses, and makes it hard to think straight. Its effects, as mentioned before, are closely parallel to oxygen want in this respect. A man is his own best judge of when to take a drink. If he has any sense he will not endanger a flying mission by preparing for it at the bar. When a flyer can drink is simply a matter of common sense.



FIRST AID IN THE AIR

First aid administered to crew members while the plane is still in the air will save many lives. To do this, however, it is imperative that you follow instructions and be calm.

The first thing to do in case of serious injury to a flyer is give him 100 percent oxygen, following instructions for use of the demand and continuous flow oxygen systems described on pages 36 to 38 .

The next thing is to stop hemorrhage. Bleeding from arteries in the head or trunk can be controlled by the application of pressure on certain parts of the body as outlined on page 80 . If not too severe, a hemorrhage may be controlled with a bandage pressing on the wound. If this fails, and the wound is in the arm or leg, strap on a tourniquet from the airplane's first aid kit. The tourniquet should be placed as close to the wound as possible, and should not be left on longer than 15 minutes at a time, or stoppage of circulation may produce gangrene. Use of the pressure points will enable you to control bleeding while the tourniquet is loosened. Remove the tourniquet when there is no further bleeding. If possible, the wounded portion should be elevated above the level of the heart.

In dressing a wound, cut away the clothing surrounding it and sprinkle with sulfanilamide powder after bleeding has stopped. Then apply the bandage from the first aid kit. The wounded flyer should swallow two sulfa drug tablets every 5 minutes until all 12 in the kit's box are used. They should be swallowed whole.

Measures against shock should be taken next. Shock may occur through exposure, fright, pain, or any catastrophic strain on the nerves alone, but usually is the result of a wound. The blood pools in the flesh and the abdomen. This stagnating of circulation causes the blood pressure and temperature to fall below normal. There is semiconsciousness, paleness, a weak but rapid pulse, and a cold, clammy skin. In addition to administering oxygen and preventing hemorrhage, you treat shock by keeping the patient quiet and warm, with feet elevated higher than the head (if there is no head injury). Give him hot coffee from the ship's thermos jug if he is conscious and not wounded in the abdomen. If severe hemorrhage accompanies the shock, the flyer should be taken as quickly as possible to a medical station where a blood plasma transfusion can be given.

Morphine, which is supplied in the first aid kit, should be injected if the flyer is in great pain. But never give morphine if he is unconscious, suffering from oxygen want, or breathing at a rate of less than 12 times a minute. It might kill him.

Burns, from flaming gasoline, incendiary bombs, or phosphorous, are a fairly common type of flying injury. The first aid rule for burns is to treat the shock first and the wound second. Most burns occur about the exposed parts of the body, the hands and face. The best burn preventives are your goggles, oxygen mask, helmet, and gloves. WEAR THEM IN COMBAT. Burned areas should be covered with burn jelly and then lightly bandaged. Phosphorous burns should be covered with water-soaked dressings.

If a bone is broken, splints should be applied before the body is moved. In a simple fracture, straighten the limb gently but steadily and apply a splint the full length of the limb. Bind the splint on firmly, but not tightly enough to stop circulation. Any flat, straight, fairly firm material can be used for a splint. If the fracture is compound (that is, if the bone has punctured the flesh) the instructions for treating a wound should be followed before the splint is put on. These include stopping of bleeding, dusting with sulfanilamide, and bandaging.

You can't do much for your wounded comrades, or they do much for you, without a first aid kit. Make sure it's always in the plane. It should never be removed unless you have to bail out and then, if possible, it should be taken with you. A smaller kit, containing fewer items, is provided for attachment to your parachute in case the larger one is inaccessible.

You can save the need for a lot of first aid by using your shoulder harness as well as your safety belt to hold you in your seat. It is especially important in ground loops and crash landings to prevent face and head injuries.

Speaking of crash landings, one of the worst things you can do when a comrade is wounded is take chances with the lives of your crew by failing to follow safe flying and landing procedures. The few minutes you may save by racing in aren't worth the risk to the patient or yourself.

STOP·BLEEDING!

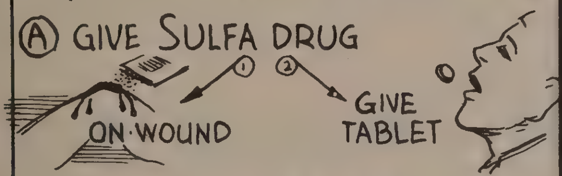
(A) ELEVATE·BLEEDING·PART.
(B) APPLY·PRESSURE *at* PRESSURE·POINTS.
(C) APPLY·TOURNIQUET·FOR SEVERE·BLEEDING.

RELIEVE·PAIN *and* SHOCK!

(A) KEEP·PATIENT·QUIET *and* WARM.
(B) ELEVATE·FEET·SLIGHTLY
(C) GIVE·MORPHINE·ONLY·FOR EXTREME·PAIN (AND·IF·PATIENT IS·CONSCIOUS.)

TREAT WOUNDS

(A) GIVE SULFA DRUG



(B) IODINE SWABS *for* MINOR CUTS.

GIVE·OXYGEN·FREELY!

(A) SEE *that* VICTIM *uses* MASK.
(B) BE·SURE·IT·IS·FUNCTIONING.

DON'T

- USE TOURNIQUET *unless* BLEEDING *is severe*.
- LET·PATIENT·GET·TOO·COLD!
- GET·EXCITED.
- CUT·OFF·CIRCULATION *with* BINDINGS *or* SPLINTS.

PRESSURE CONTROL OF HEMORRHAGE

To know how to control hemorrhage from arteries in different parts of the body, learn the points shown on the opposite page and described below. It is simple with a little practice at putting your fingers on the right spot. These are as follows:

1. If there is bleeding in the scalp above the ear, apply light pressure in front of the middle of the ear, where an artery can be felt throbbing.

2. Bleeding in the cheek may be stopped by very light pressure in a notch on the under edge of the jaw two-thirds of the way back from the tip of the chin, where a small artery crosses.

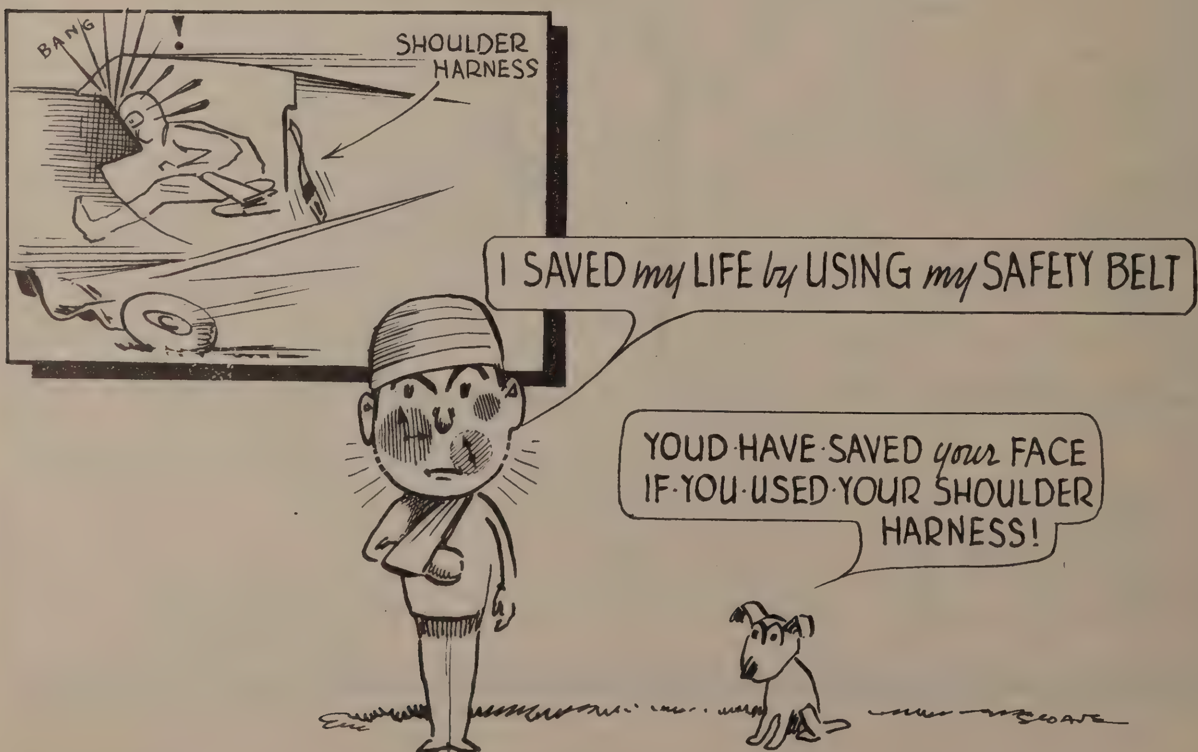
3. Bleeding either on the outside or inside of the head may be controlled by moderate pressure on the neck about a hand's breadth below the ear and about halfway between the jaw and the collar bone. The large artery there is pressed against the spinal column.

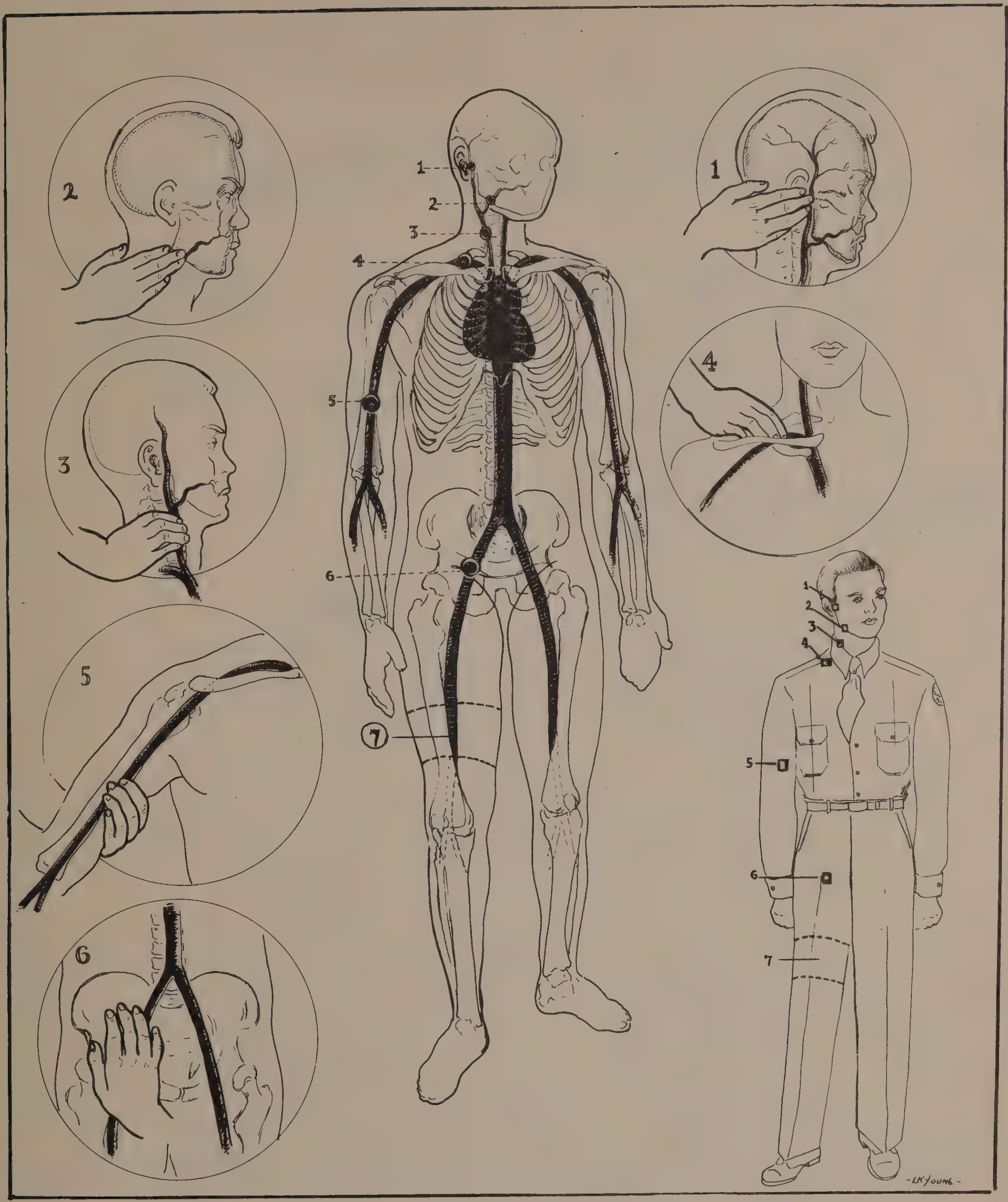
4. Bleeding in the arm can be stopped by firm pressure behind the middle of the collar bone. The artery is pressed against the first rib.

5. Bleeding in the lower arm can be stopped by strong pressure on the inside of the arm halfway between the shoulder and elbow. It will cause the pulse to disappear. A tourniquet applied at this point will stop hemorrhage in the forearm.

6. Bleeding in the thigh and leg can be stopped or decreased by strong pressure in the groin with the heel of the hand, pushing the artery against the pelvic bone.

7. Bleeding below the knee can be controlled with a tourniquet applied halfway between the crotch and knee.

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-LKYOUNG-

WHAT'S INSIDE YOU AND WHERE

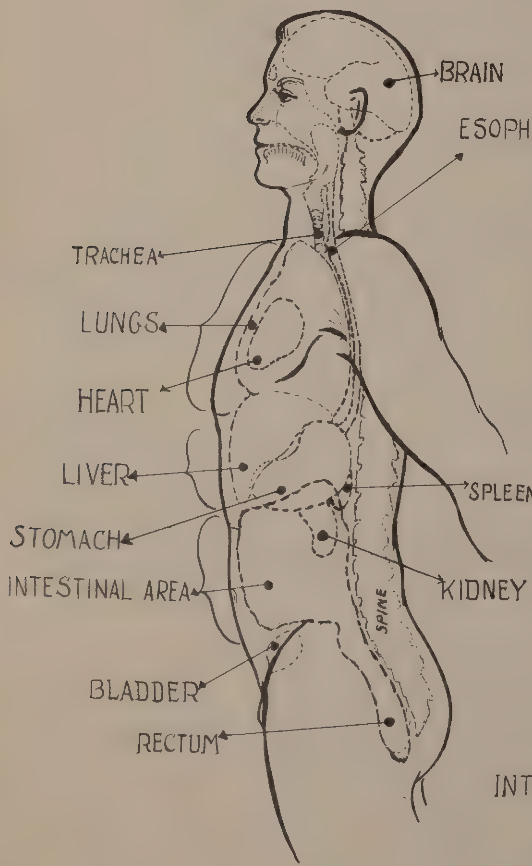
The location of the principal internal organs in relation to the outside of the body is diagrammed on the opposite page. A quick study of the two views, front and side, will give you some idea of what organs may be hit if a bullet strikes at any particular spot.

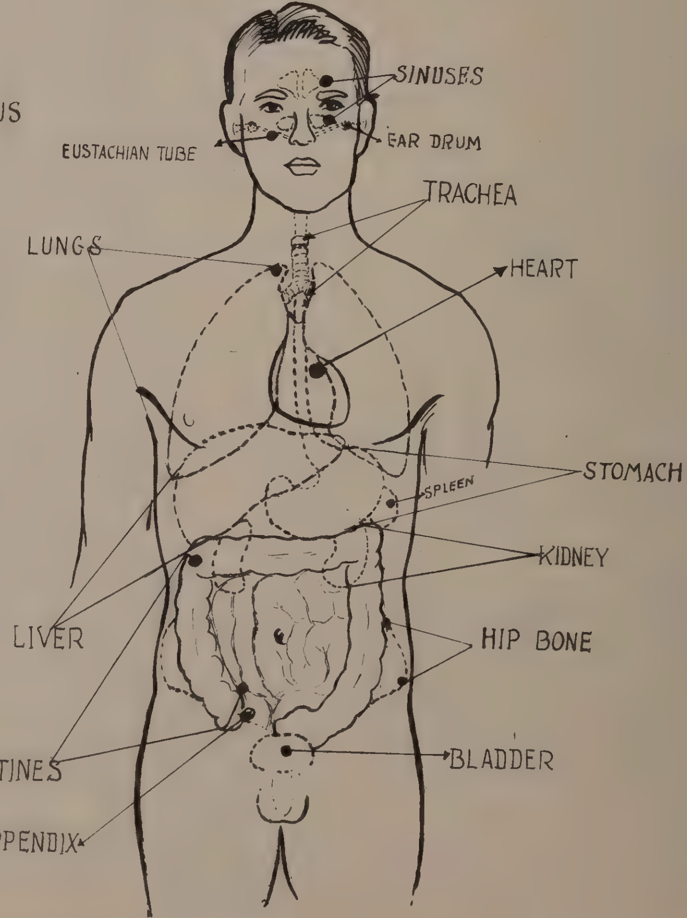
The first aid measures which can be carried out to save a man with internal injuries are limited. He must be moved to a hospital to receive adequate surgical and medical attention. There are, however, several important points to be remembered in emergency care of head, chest, and abdominal wounds.

In addition to general first aid as outlined on pages 77 to 80, head injuries require frequent cleansing of mouth and nose with a wad of gauze to remove secretions which might interfere with breathing. Laying the patient with his face down will aid this removal.

A hole in the chest wall should be closed with adhesive tape, a large, thick dressing, or both. This is to prevent air from leaking into the chest cavity and collapsing the lungs.

KNOW YOURSELF!





There are two don'ts for wounds involving the stomach, liver, kidneys, and intestines: Don't permit the patient to move. Don't give him coffee or any other liquids to swallow. The abdomen should be tightly wrapped with overlaying pressure bandages to reduce internal bleeding. If the intestines spill through an open wound, don't push them back in unless it is certain that they are not punctured. If they are, they should be covered with gauze compresses which must be kept moist with a reasonably sterile, preferably warm, liquid. The compresses should be held in place with a fairly snug bandage. If the exposed intestine is not punctured, it should be sprinkled with sulfanilamide powder and gently pressed back into place in the abdomen with compresses. Then bandage the wound.